THE ENGINEERING RECORD

Published Weekly by the

McGraw Publishing Company

MAIN OFFICES:
114 Liberty Street, New York.

BRANCH OFFICES:
Philadelphia: Real Estate Trust Bldg.
Chicago: 1140 Monadnock Block.
Cleveland: Cuyahoga Building.
London Office: Hastings House, Norfolk St., Strand.

SUBSCRIPTION RATES:
United States, Canada, Cuba and Mexico....$3.00 a year.
Foreign subscription .... 6.00 a year.
25 shillings. 25 marks. 31 francs.
Foreign subscriptions may be sent to our London office.

NOTICE TO ADVERTISERS.

Changes in advertisements intended for a particular issue should reach the office of The Engineering Record by 10 A. M. Monday of the week of issue. New advertisements can be received up to noon of Wednesday of the week of issue.

NOTICE TO SUBSCRIBERS.

Remittances.—Remittances should be made by check, New York draft, or money order, in favor of The Engineering Record.

Changes of Address.—The old address should be given as well as the new, and notice should be received a week in advance of the desired change.

Back Copies.—No copies are kept on sale beyond fifteen months from date of issue, except in bound volumes.

Entered at the New York Post-Office as Second Class mail matter.

Copyright, 1906, by the McGraw Publishing Co.

Of this issue of THE ENGINEERING RECORD 13,000 copies are printed. Total circulation for 1906 to date 244,000 copies, an average of 12,842 copies per week.

TABLE OF LEADING ARTICLES.

Conditions Necessary for Bidding on Municipal Contracts 581
The New Aspect of Architectural Registration in Great Britain 581
Horizontal Return Tubular Boilers for High Pressures 582
The Investigations of the Committee of Twenty.... 582
The Pedlar River Concrete-Block Dam, Lynchburg Water-Works. (Illustrated).................. 584
The Effect of the Earthquake at Stanford University, Cal. (Illustrated).................. 586
The Cause of the Earthquake.................. 588
Comments of Californian Engineers on the Earthquake and Fire. (Illustrated).................. 588
The Saving of the Western Electric Building at San Francisco 591
Early Asphalt Pavements in London.................. 592
Recent Tunnel Construction of the Rapid Transit Railroad in Brooklyn. (Illustrated).................. 593
Relining the Allegheny Tunnel, Pennsylvania Railroad. (Illustrated).................. 597
Fireproofing the Steel Work in a Large Office Building. (Illustrated) 598
Test of a Turbine-Driven Sirocco Blower.................. 599
Central Heating Plant for Park College, Parkville, Mo. (Illustrated).................. 600
Waterproofing the Substructure of the West Street Building, New York. (Ilustrated).................. 601
The Equipment of Two Berlin Power Plants. (Illustrated).................. 602
Heating the Edgar F. Smith Dormitory, University of Pennsylvania 603
Cost of Dams for the United States Reclamation Service.................. 604
A 122-Ft. Four-Track Plate-Girder Span. (Illustrated).................. 605
Reinforced Concrete Floors in a Chicago Warehouse. (Illustrated) 606
Hollow Concrete Foundation Piers. (Illustrated).. 607
Book Notes 607
Engine Wrecks from Cylinder Water.................. 608
American Institute of Electrical Engineers Vote on the Metric System.................. 608

Conditions Necessary for Bidding on Municipal Contracts.

Some attempts recently to let contracts for large municipal works in the City of New York have raised serious questions regarding the necessary conditions on which advertisements may be made and contracts awarded. Comment was made in this journal but a short time ago on a taxpayer's suit brought to invalidate the contract awarded to the Pennsylvania Steel Co. for the steel work of the Manhattan bridge on alleged uncertainty as to some items of work covered by the proposed contract. Again, within a few days, the Commissioner of Bridges has been enjoined from opening the bids received in another attempt to award a contract for the steel superstructure of the same bridge on the ground that the absence of a stress sheet in the plans submitted for the information of bidders prevented the latter from acquiring sufficient information to make a legal bid. Both of these attempts to prevent the award of contracts must have been made or inspired by unsuccessful bidders or by parties inimical to the proposed plans, and hence their actions were prompted by other reasons than an unselfish desire to ascertain just what conditions are necessary or sufficient to make advertisement for tenders or awards of contracts legal. The mere fact, however, that serious obstructions to the award of contracts can be raised on such grounds indicates the existence of doubt in the minds of the judges as to the sufficiency of certain conditions on which many contracts for large municipal works have heretofore been awarded and executed without opposition.

Unquestionably it is difficult for a judge in any court either to appreciate or to interpret the technical features of the plans and specifications prepared for the letting of contracts for such a class of work as the great bridges proposed by the City of New York for crossing the East River. It is highly probable that herein lies the whole difficulty. An interested party who wishes to interpose in the award of a contract sets up an objection of such a character that the evidence bearing upon it and submitted to the court is of a purely technical nature. The alleged defects of plans and specifications are plausibly set forth and the evidence under certain conditions would be incontrovertible, but on the other hand, under the conditions of a given proposed contract no such defects whatever may exist. The court, being unable to make the necessary technical distinction, is completely in the dark as to the proper course to be taken and the judicial decision is fully as likely to be wrong as right.

An experienced engineer prepares his plans and specifications, constituting the necessary information for bidders, with a view to the kind of a tender which he solicits. In the case of a great undertaking like that of the Manhattan Bridge, he may or may not prepare full detailed plans showing dimensions of all members with the number and location of rivets and other details. If prospective bidders are requested to tender for the job at a pound price or at some other unit price for the various classes of work involved, full detailed drawings are not necessary. The entire information needed by the bidder comprises the principal dimensions of the main members with typical plans of details or other equivalent information explaining their character. It is usual to exhibit the composition of all main members, including dimensions of cross-section and cross-sectional areas on a stress sheet, showing also the stresses which the different members of the structure must carry. The stresses shown on the stress sheet are not at all necessary for the information of the bidder, but they are of incidental use to him and the sections of main members are usually given in connection with the stresses which act on them.

In the other case, where complete detailed plans of all parts of the structure are included in the information given to bidders, the latter require no other plans whatever for their information. All parts of the structure under such circumstances are shown on the contract plans. Not only the make-up of the main members is exhibited, but there are given all dimensions of every part, including details of every kind and even the number and location of rivets. With such plans before him and with the specifications available for the data which he needs, every prospective bidder can estimate the exact quantity of each and every class of material with exactness and certainty. He has, therefore, all that he requires to make tenders either on a unit price basis or for a lump sum price, without any stress sheet whatever. Indeed, with complete detailed plans for the work before him, the stress sheet is entirely superfluous and if any attention were given to it, it might even confuse him.

In either case the successful bidder would prefer, in accordance with the usual custom in such matters, to prepare the shop or working plans so as to insure such details and procedures of manufacture as may best suit the administration and practices of his own bridge shop. Furthermore he may desire to suggest various changes or modifications of details so as to better conform to the capacity or adaptability of his own shop methods. Obviously, such changes and modifications would be made only under the approval of the responsible engineer of the municipal department paying for the work. They are, however, both requested and granted to a sufficient extent to justify making provision for them. To accomplish this end it is convenient to include in the specifications the unit working stresses permitted, but a stress sheet would be of no real service whatever to the bidder.

All these general conditions have been fulfilled, and yet the various attempts made to get the work of the Manhattan Bridge under construction have thus far been blocked by alleged defects of uncertainty or lack of definition in the specifications and information given to bidders. Inasmuch as the conditions under which it is proposed to award this work are identical with those attending the awards of the great bridges heretofore built by the city the objections set up in this instance seem rather finely drawn.

The New Aspect of Architectural Registration in Great Britain.

For something like two years the Royal Institute of British Architects has been like a house divided against itself over the question of registration, or some other form of licensing, as a requisite for practicing the art. This agitation has not been confined to Great Britain, for it has been the subject of many warm discussions in the United States, and some of the States have already adopted laws requiring architects to be examined and licensed before practicing. Nominally the reason for such a course is the desire to protect the public against the danger of insecure construction due to the planning of buildings by persons without adequate knowledge. Practically, however, the agitation for registration among architects has come from people in the smaller communities who feel most keenly the competition of the aspiring carpenter or the soaring mason, who has abandoned the saw and trowel for a T-square and a volume of ready-made plans. It is an indubitable fact that among the provincial architects in Great Britain there has been an idea that through registration or some such scheme their professional status would be improved and the shadow of the Royal Institute would help them with many of the little difficulties which beset their practice.

The feeling which was aroused in this manner finally led the Institute to appoint a committee two years ago to consider the question of registration; this committee represented not only the Institute but also the allied societies. Its proceedings were disturbed by elections which threw out some of the representatives of the Institute and substituted others, but finally its recommendations were embodied in the form of a bill which it was proposed to submit to parliament. This aroused a storm of protest which seemed to shake the very foundations of the Institute. The committee in charge of the subject was again reconstructed by a change in the representatives of the Institute, and decided that it was not wise to rely on its own knowledge in such a debatable matter. Accordingly six eminent metropolitan and six leading provincial architects in favor of registration and a similar number of those opposed to it were asked to appear before a sub-committee and state their views very fully and frankly. The witnesses in favor of registration felt strongly that the standard of architectural ability would be raised by some sort of compulsory training and examination; and also that, in the interests of the public and profession alike, only those who had proved their competence by passing a qualifying examination should be legally entitled to call themselves architects. On the other hand there was an equally strong feeling that the proposed measure would have the tendency to lower the art of architecture, and that, as the test to be applied must be a low one in the opinion of many, there would inevitably be a tendency to register very poorly qualified men; and that, though examinations might fairly test a man's constructive knowledge, they could not fix a standard in art.

After considering the information it had collected, the committee reached the conclusion that the bill formerly proposed was impracticable, an opinion that was well founded by the conditions as they present themselves to an outsider. There can be no question that some diploma of proficiency would improve the standing of competent architects in the smaller towns, but even the Institute's members on the committee who favored registration came to see that unless the profession approached parliament with an essentially unanimous front there was not the slightest chance of securing any legislation. The recognition of this fact, while it took two years of debate and argument, was well worth the delay. The episode is, in fact, an excellent one in proving the desirability of careful investigation of any project which will affect the condition of an entire profession. In discussing such subjects, any attempt to secure quick action is certain to result in decisions so unsatisfactory to many of the members that what should be a benefit to the society really becomes a source of dissension. By taking plenty of time to discuss the subject in committee before presenting it to the Institute, a project was at last formulated which seemed to meet with hearty favor when it was finally submitted.

This new project for raising the standing of the architectural profession in Great Britain is a startling one. It contemplates a change in the charter and also the submission of a bill to parliament. The name is to be changed to the Royal College of Architects, and after the current year no one is to be elected to the grade of fellow who has not passed the associates' examination, except certain men elected by the council in special cases. In harmony with the change of name it is proposed to adopt a scheme of education to be compulsory on all candidates coming up for admission to the Institute after 1912, and to ensure a proper respect for professional ethics the disciplinary powers of the Institute are to be increased. There are many bona fide architects in Great Britain who are not members of the organization, and in order that no hardship may be suffered by them it is proposed to enroll them in a new grade of membership, to be known as licentiates, admittance being granted without examination by the council and to be closed within a year after the passage of the act by parliament. This act follows the precedent of that governing the Law Society, by requiring the Royal College of Architects to supervise the education and examination of architects for admission to its ranks, legalizes the schedule of charges and gives statutory force to the charter; it is also hoped that the act will be so drawn as to require public bodies engaged in erecting public buildings to employ a member of the College.

It will be noticed that there is nothing about this project to prevent unqualified persons from practicing as architects. People might go to them just as they now go to medical quacks, but it would be at their own risk. The publicity which the College could give to its educational work and its examinations would speedily put the unqualified practitioner out of the running for all work of any importance, which was the main object in view during all these years of study and controversy. This project is now before the council of the Institute for its consideration, and will be referred back to the members at a later date for further general discussion. Although the feeling on the general subject of registration ran so high a year ago that heated was a mild term to employ in designating it, the report of the committee embodying the above suggestions was received with unanimous and marked approval. The whole course of the agitation from its inception to the present condition of harmony affords a very striking example of what can be done by impartiality and tact in the handling of society affairs of importance where differences of opinion are pronounced.

Horizontal Return Tubular Boilers for High Pressures.

The tendency of modern practice is toward the use of high steam pressures, and one of the arguments against the externally-fired horizontal shell boiler is that it is unfitted to withstand for unlimited periods the strain the pressure and firing entail. It is not that the shell cannot be made strong enough for any desired pressure, for increased thickness of plate can always be provided and there is no difficulty in any particular as regards construction. The obstacle in the way of using high pressure on shell boilers externally fired comes from the effect of the furnace heat on the thicker metal. Theoretically, the transmission of heat through metal is so rapid that thickness in the boiler plate is of little consequence; but, practically, thick plates exposed to the fire, especially at seams where there are two thicknesses, waste or burn out and their strength is correspondingly impaired. The rapidity of this action depends upon the cleanliness of the interior surfaces and the character of the water, but under the best conditions there is a limit of thickness beyond which it is impracticable to go. This limit is generally placed at five eighths of an inch, and it is only occasionally that plates as thick as this are used for externally fired shells. There is another reason. The continued strain on boiler plate in service is believed to gradually undermine its mechanical structure and reduce its elasticity so that after a few years the plate is less serviceable than it was when new. The deterioration from this cause is most rapid in the furnace plates, where the strains due to heat are added to those produced by pressure. Three causes are, therefore, operating in externally fired boilers to reduce their strength, namely, the burning of the sheet, the deterioration in elasticity due to the continued strain arising from pressure, and the reduction of elasticity due to the strains produced by the furnace heat.

There is a method of overcoming these objections, pointed out some years ago in this journal, and deserving mention again. It is the use of a firebrick arch sprung over the entire space beneath the shell, protecting the bottom sheets throughout their whole length from the heat of the furnace. The products of combustion first strike the heating surface when they enter the tubes at the rear end of the boiler. The heat which comes in contact with the external shell is simply that which is conducted through the arch and radiates from its upper surface; and this, of course, is of comparatively little account. The method sacrifices the heating surface of the outside shell and introduces the objectionable feature of a brick arch, which deteriorates under the action of the extreme heat, and it must from time to time be renewed; but the system renders practicable the use of high pressures on externally fired boilers, which, in the absence of this protection, is not to be generally recommended.

The Investigations of the Committee of Twenty.

Probably a considerable number of the readers of this journal have asked what is the Committee of Twenty and what is it doing that so much attention has been paid to it in some cities. "What's in a name" is certainly an appropriate query concerning a body bearing such a meaningless title. It is unfortunate that this title is so devoid of significance, for the committee is composed of representatives of the National Board of Fire Underwriters who, with the assistance of a large engineering staff, have been investigating the condition of all the important cities of the country with a view to determining accurately the fire hazard in them. The results of these investigations and studies in each city are embodied in a special report for that place, bringing together in concise form all the information needed to acquaint city officials and business men with the basis on which fire insurance affairs in their community must be conducted.

Since the primary object of the work is to determine so far as possible the nature, extent and means of reduction of the conflagration hazard in each city, the individual reports are arranged in each case so as to lead up to a discussion of this hazard, which can be appreciated only with a complete knowledge of the features affecting it. Obviously it would be impracticable to elaborate every detail, and the reports, which have sometimes been criticised as long, contain but the essence of facts too numerous to be submitted undigested. No business man or city official could profitably take the time to weigh each fact in its relation to all others, as was done in the preparation of the information given in these documents. Furthermore very few people have had the training necessary to balance correctly the data obtained and reach a final conclusion. The statement made within a year in one of these reports that San Francisco had defied all insurance precedent by remaining unburnt found definite confirmation in the events of last month, but was probably ridiculed by many residents of that city. The conclusions given are based on the deductions of men specially qualified to analyze and reconstruct the great accumulations of data in their own particular specialties, and consequently are particularly valuable to engineers who have to design many kinds of public works as well as to architects and owners of buildings.

For the information of readers who have not seen one of these reports it may be said that a good many factors are considered of importance in determining the conflagration hazard, which are not generally understood to bear any relation to it. Even the general organization of the city government is deemed of importance and is explained at some length in each report. The effect of some details of organization is often considered detrimental to the insurance interests. In Boston, for example, the control of explosives and inflammables has been taken out of the proper hands and put into those of the State Fire Marshal. In New York, the Fire Chief has not sole disciplinary powers. In other places building commissioners are subject to the caprice of a mayor. The records of property values and the tax rate in each city are also of importance as indicating what resources a city has to enable it to better its general fire protection facilities. The population and the rate of its growth are similarly considered of importance, sometimes of vital importance, in determining the proper insurance policy to follow with a city. The topography of a city is significant as indicating the grades to be mounted by the fire apparatus, the character of the water distribution and the exposure of buildings and districts. Newburgh, San Francisco, Dubuque, Duluth, Seattle and Kansas City are examples of cities subject to peculiarly spreading fires on account of their unevenness. Chicago's flatness and the location of its river are the cause of the special characteristics of its danger district.

The number of things that affect the fire hazard is really surprising. It has already been mentioned that the grade of streets is one of these, but the pavements is another. The actual nature of the pavements is not so important as the character and frequency of the permanent and temporary obstructions to be found in it, and the regulations concerning the opening and closing of the street surfaces. Disabling of fire apparatus in New York is frequently caused by the elevated railway structures. Apparatus in other cities often plunges into street openings the presence of which has not been made known to the fire department. Heavy apparatus frequently has to be turned back in a block in which repairs are going on, perhaps to be followed by a ladder truck and hose wagon, thus wasting valuable time. Little heed is paid to these things by most people although they cost hundreds of times the expense of avoiding them. Another factor to be considered in a study of the conflagration hazard of a city is the direction and average velocity of the winds. Any city with a high average wind velocity is bound to give its firemen hard problems to solve. The same attention must also be paid to temperatures, for the prevalence of freezing weather brings additional chances of fire and special difficulties to the fire department.

The problems of water supply and of fire department organization and equipment of course receive much attention in these reports and it is interesting to observe the different points of view of the fire protection engineer and the hydraulic engineer. One significant fact is the favor shown to municipal ownership of water works tending to provide better fire-fighting facilities. The Committee of Twenty has stated, in a brief way, the essential fact governing this opinion: "A water system, very poor from a fire-protection point of view, may be and often is a profitable investment to its owners." The insurance interests are by no means the opponents of meters, as sometimes asserted, and the Committee states in so many words that "the elimination of waste by the introduction of meters and proper restrictive measures has often postponed for years costly extensions, enabling a municipality to undertake other needed reforms." The information in the reports concerning the building department, building laws and the local building conditions is, naturally, given in much detail.

Enough has been stated in this brief summary of some of the features of these reports to indicate the importance of the work done by the Committee of Twenty and the value of its reports. To the engineer they are specially instructive, for they furnish a discussion of many features of engineering design and construction from a point of view that is rarely given full consideration. The lessons of San Francisco, ruined by fire, and Oakland, practically uninjured, although both were subject to the same earthquake shocks, ought to be carefully studied, and technical schools will render considerable aid to the cause of sound municipal building by pointing out from time to time to their students the importance of avoiding methods and designs tending to increase the danger of structures and cities from serious conflagrations.

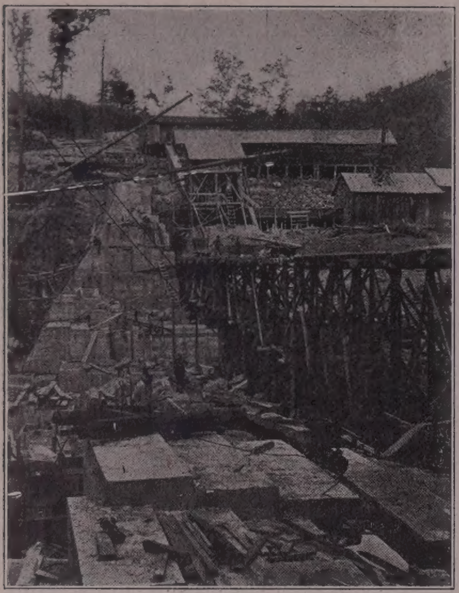
Notes and Comments.

Flue-Gas Analysis in the dock yards of the British Navy are made by a portable apparatus described by Mr. C. J. Wilson in a paper published by the Institution of Civil Engineers. It consists of a water-jacketed eudiometer tube, containing 50 c. cm. between the two extreme marks, and divided into 100 parts for convenience of calculation; an absorption vessel of simple design connected to the eudiometer by means of a three-way glass stop-cock, and two movable mercury vessels, one at each end of the system, for transfer of the gas from one vessel to another and for suction and expulsion of the sample of gas into and out of the apparatus. The absorbing reagents used for estimation of the various components of the flue-gases are kept in stock bottles outside the apparatus, and a small quantity of each is sucked by the three-way cock into the absorbing vessel when required. After each absorption the reagent is expelled, and the absorbing vessel is washed out with water before another determination is made with it. For CO_2 a strong solution of caustic potash is the absorbent used, for oxygen an alkaline solution of pyrogallic acid (mixed in the absorption vessel), and for CO a solution of cuprous chloride in ammonia is employed. It is claimed that the use of mercury diminishes the error due to absorption and losses in the eudiometer tube, and that the use of fresh reagents for each absorption and of only one absorbing vessel diminishes the errors to other causes.

The Chicago City Hall has been the subject of so many alarming statements in the papers lately that it is interesting to observe the freedom from anxiety concerning it displayed in a report by Messrs. E. C. Shankland, Louis E. Ritter, Martin Vatterberg, Henry E. Cordell and Alfred E. Mace, a commission appointed to investigate the condition of this structure. Their statements to the Commissioner of Buildings read as follows: "We have made a careful examination of the city hall with reference to the effect caused by the digging of the caissons of the new county building and beg to report as follows: We find no evidence that the digging of the caissons has caused any damage to the building sufficiently serious to endanger its safety. The ceilings and walls of the sub-basement where the jail cells are located are badly cracked and should be thoroughly gone over and repaired wherever necessary. Throughout the building the settlement has caused serious loosening of the plaster, the wood trimming and ornamental portions of the exterior stone work. This condition is now a menace to the occupants of the building and to the public passing it. All this work should be carefully gone over by competent persons and all loose material taken down at once." Apparently, however, this opinion is not to be accepted by some of the municipal authorities, and the cracks and fallen ceilings are to be made the basis of an agitation for a new city hall. Such a building is desirable, but Chicago needs so many other public improvements of various kinds that the early construction of a new structure may not be the best use to make of the funds now available for public purposes.

The Resistance of Masonry to Earthquakes is well shown by the condition of the buildings at Leland Standford, Jr., University, described elsewhere in this issue by Prof. C. D. Marx. Those structures where the walls were of concrete or brickwork in good cement mortar are practically uninjured. This testimony is, in some respects, the most important yet received from California, for it establishes a fact concerning masonry construction that is likely to be overlooked in these days of wretched bricklaying. So much work of this sort is for the purpose of curtain walls and other constructions carrying trifling loads that old-fashioned bricklaying resulting in a strong and durable wall is becoming a lost art. What Prof. Marx says about the buildings of Stanford University is strongly backed up by the condition of the Palace Hotel in San Francisco. That structure was built years ago, when brick masons laid good walls. As a result its walls were uninjured by the earthquake and the subsequent fire, and unless the owners of the hotel decide to erect a building of more modern arrangement on the site they can use the walls now standing without much repair. In considering the effect of the earthquakes on these buildings it would be very interesting to know the position of their main walls relative to the line of movement of the shock. This consideration may be important in some cases, as is shown by the effect of the earthquake on different trains. In some cases they were thrown from the tracks, while in others they were not swayed materially. So far as can be learned now, this difference of effect was due to whether the earth tremor was along or across the track.

The Prevention of Water Waste in Massachusetts has reached at last a condition of the same importance that it has long held in Great Britain. The manufacturers along the Ware River, employing from 25,000 to 35,000 people, view with alarm the prospect of an appropriation of a large part of the water of that river for the communities supplied by the Metropolitan waterworks, and they have accordingly secured the passage of a bill which will ensure the prevention of water waste. These manufacturers and others throughout the Commonwealth acknowledge that the legitimate requirements of cities must be met, but they protest against the construction of works taking the water they require in their industries, if this water is subsequently largely wasted. The Metropolitan board has stated that if the waste of water is checked the construction of new works can probably be deferred for a considerable term of years, and the experience of communities supplied with Metropolitan water affords striking proof of the accuracy of this statement. Moreover it seems that the introduction of meters has not only cut down the waste of water but it has also resulted in some cases in a lowering of the cost of the supply to individual consumers. The position of the Metropolitan board on the subject is expressed officially as follows: "It is believed that such early expenditures as may be required for inspection and measurement of water will be within a reasonable period offset by the saving which will result. Not only efforts for the reduction of the consumption would seem demanded for the interests of the municipalities of the Metropolitan district and the individual water takers, but the Metropolitan district cannot properly ask other portions of the Commonwealth to submit to burdens and sacrifices in order to provide the cities and towns of the Metropolitan district with a water supply, unless the district itself takes all reasonable efforts to make such burdens and sacrifices as light as possible." The legislature has accordingly passed an act requiring all cities taking their water supply from outside their city limits to meter every new service that is installed, and of the unmetered services on Jan. 1, 1907, 5 per cent. must be metered annually. Incidentally this conclusion is the most important confirmation yet given to the views long held by this journal, that water meters afforded the cheapest and best method of preventing all waste.



Pedlar River Dam under Construction.

The Pedlar River Concrete-Block Dam, Lynchburg Water-Works.

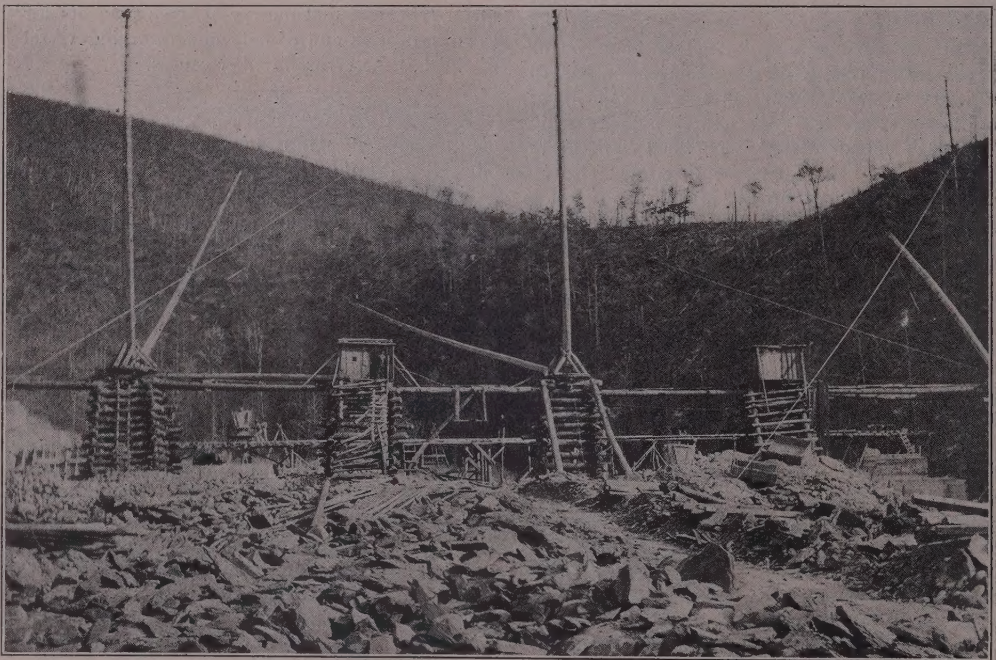
The city of Lynchburg, Va., has under construction a new water supply planned to yield, for the present development, about 8,000,000 gal. of water daily, from an impounding reservoir formed by the construction of a concrete dam across the Pedlar River, about 30 miles from the city. The general features of the dam and pipe line were illustrated in The Engineering Record of July 23 and 30, 1904. This description was prepared from the preliminary designs and specifications of the work and although the construction has conformed very closely to it there have been a few modifications developed by the requirements of the work, as indicated by the slight discrepancies between the previous article and the present one.

The dam has a straight axis approximately perpendicular to the contours of the steep sides of the narrow rocky valley which it crosses. It is about 500 ft. long on the crest and has a maximum height of 73½ ft. There is a spillway 150 ft. long and 10 ft. below the crest, which has granite steps from 4 to 7 ft. apart vertically and is about 44 ft. wide at the base. The remainder of the dam has a crest 10 ft. wide and a foundation 49 ft. in maximum width. As it is thought possible that the flow over the spillway may attain a depth of 6 ft. in extreme flood and thus tend to produce a partial vacuum under the falling water, provision has been made to vent this surface and thus prevent the development of unbalanced atmospheric pressure which, under extreme conditions would add some 12 tons per running foot of dam to the water pressure. This is effected by the introduction of a horizontal 6-in. vitrified pipe line running through the concrete close to the face of each step. Both ends of the pipe line are open and project beyond the faces of the wing walls and three 3-in. outlets are made from the pipe in the face of the masonry. This provision is considered especially desirable on account of the height of overflow, 60 ft., which is among the highest yet constructed.

The top surface of the spillway steps and the crest of the dam are made of tough blue granite. The spillway steps are made of rock-face stones 20 to 26 in. thick and 5 to 7 ft. long, no beds being less than the depth of the stone. They project into the concrete to form a strong bond, and are laid with 1-in. joints. The stones in the crest are 2½ ft. thick and are bonded together with horizontal steel dowel pins, which engage long U-shaped anchor bars of ⅝-in. twisted steel, reaching to the opposite face of the dam, and are built solid into the concrete. At each side of the spillway there is a reinforced concrete wall 5 in. thick which rises 10 ft. above the spillway steps. The 18x25-ft. gate house is made integral with the dam masonry and is built above the crest of the latter, with granite walls and a metal roof. The remainder of the dam is built entirely of cyclopean concrete with foundations carried down to solid rock.

The concrete is special in that it is made in rectangular blocks built in position in forms with dimensions varying from about 20 to 90 cu. yd. each. The blocks have vertical faces, are stepped off on the top and bottom surfaces, and are arranged by the engineer in very irregular positions at different levels so as to insure the absence of continuous joints in any direction through the dam. Rectangular grooves 12 in. wide and 4 in. deep are made horizontally across the front and rear sides of each block and vertically across the ends, so as to form expansion joints into which the concrete of the adjacent blocks is worked, to form solid tongue-and-groove connections uniting all of the blocks in the dam.

The gate-house projecting from the upstream face of the dam contains two rectangular wells separated by a partition so as to form inlet and outlet chambers. It is somewhat special in the provision made for controlling, excluding and emptying the water, so that all portions of it are easily and quickly accessible without the use of stop planks. The water is admitted from the reservoir through three 24-in. intakes commanded by gate valves operated from the top of the dam. One intake is 10 ft. above the bottom of the reservoir, another is 10 ft. below the top and the third is midway between them. All of these are in the end wall of the gate-house and have cast-iron pipes parallel to the face of the dam. The inlet chamber is provided at the bottom with two 4-ft. sluice gates, one on the side toward the reservoir and the others controlling the 4-ft. water waste or blow-off pipe. Between the inlet and outlet chambers there are two sets of sectional vertical sliding Coldwell-Wilcox bronze wire screens of ⅛-in. mesh. These have a total height of about 50 ft. and are operated by a hoisting gear which allows one set to be removed for cleaning while the other is in service. At the bottom of the outlet chamber there is a 30-in. valved cast-pipe connecting with the conduit line to the city of Lynchburg.



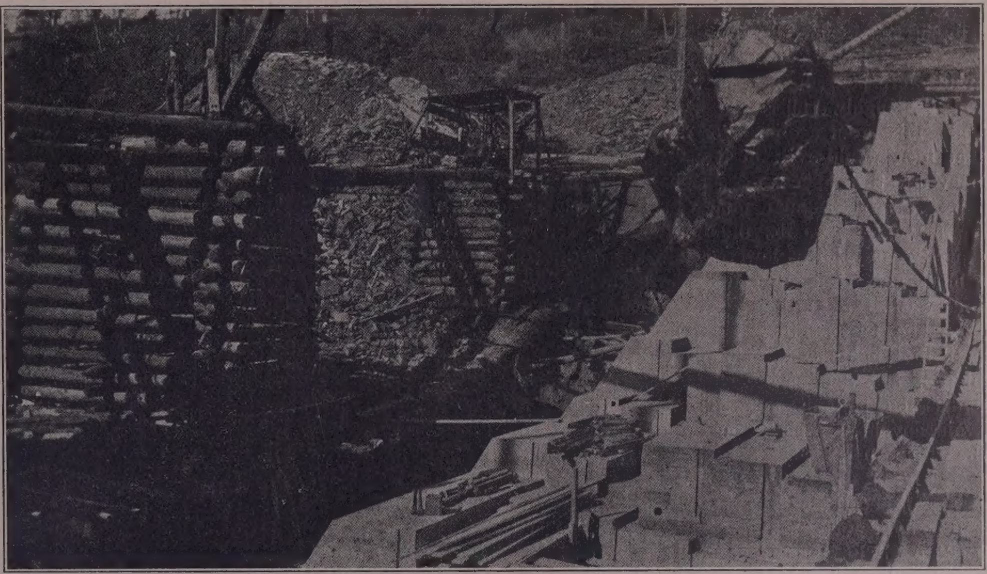
Main Derricks on Falsework Towers.

The construction of the dam requires a total excavation of about 4,000 cu. yd. of rock and 2,000 cu. yd. of earth, and the structure will contain about 22,000 yd. of 1:2:4 concrete made with old Dominion Portland cement, 500 yd. of cut stone and about 10 tons of twisted steel, which is used for reinforcement in certain places.

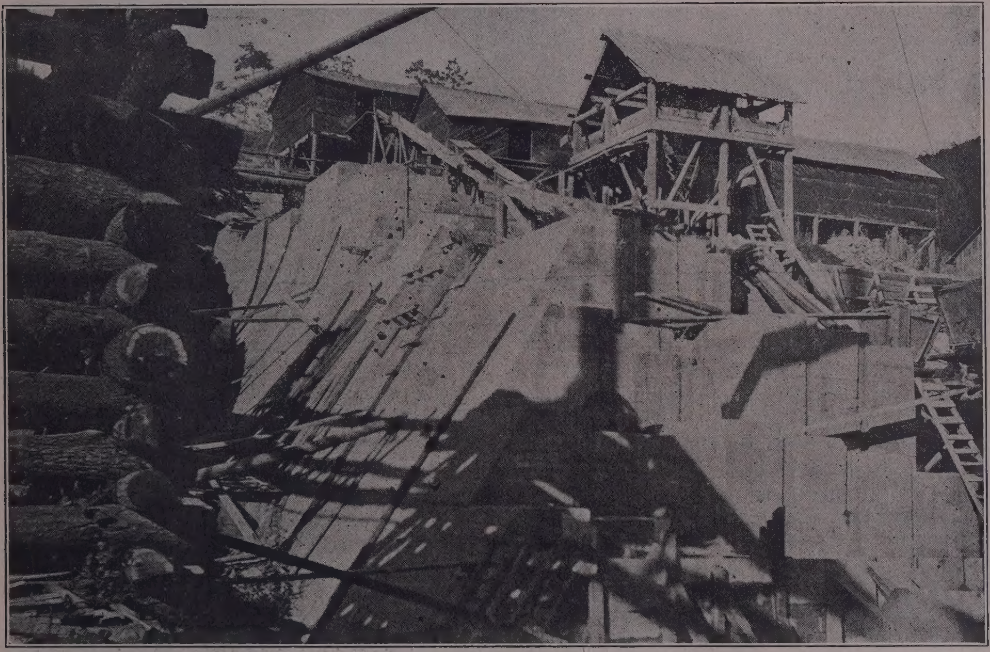
At the dam site the bottom of the valley is nearly horizontal for a width of about 200 ft. At the spillway end of the dam the banks rise very precipitously and at the opposite end they slope more gradually. The formation here is of shale rock, badly decomposed on top, and had to be excavated from 5 to 15 ft. to secure solid footings for the foundations. The river has a minimum flow of about 2,000,000 gal. a day, the original dry weather channel being about 20 ft. wide and 2 ft. deep. Occasional sudden floods are encountered, but fortunately these have been somewhat small and infrequent since the commencement of the work.

The original bed of the river followed close to the steep side of the valley and in order to commence operations temporary dams were built across it at points just below the permanent dam and about 500 ft. above it. These were constructed of trees felled across the channel, with supporting walls of inclined boards against which earth and stone were dumped, and diverted the flow of the river through a canal cut parallel to the original channel and intersecting the line of the dam near the center point. Excavations were made on each side of the new channel for about two-thirds of the foundations of the dam. After the concrete has been extended across the old river bottom a sluice way 6 ft. wide and 3 ft. deep was built across the dam, at the level of the original river, and, by the removal of the temporary diversion weir, the river was again turned back into its original channel and carried across the dam site in the flume. The remainder of the concrete in the foundation was then laid. The 4-ft. blow-off pipe through the bottom of the dam was then set at about the level of the finished bottom of the reservoir, and the first section of the gate-house ran the portion of the dam back of it, with the wash channel, completed, and, after the remainder of the dam had been carried to a sufficient height, the flume was removed and the flow of the river diverted through the blow-off pipe. Floods exceeding in rate of flow the capacity of this pipe at the head available are passed over the top of the solid concrete without injury to the work.

Excessive pumping was not required in the excavation and the foundations were built with comparatively little difficulty. The sand used on the work is dug from the bottom of the reservoir about half a mile above the dam and as it then contains from 15 to 30 per cent. of clay, loam and vegetable matter, it is washed, and this amount is reduced to 2 to 5 per cent., thus furnishing a clean and desirable sand for mortar and grout. A log and dirt temporary dam diverts the water of a small creek into a wooden flume 2 ft. wide, 1 ft. deep and about 100 ft. long, which has a 1 per cent. grade and terminates in a double box 16 ft. long, 3 ft. deep and 12 ft. wide. This box is divided by a central longitudinal partition having a gate vertically hinged to the upper end, so that it can be thrown in either direction to divert the sand and water into either chamber. The sand is shoveled from wagons into the upstream end of the flume and is washed by the flowing water down into one or the other of the sand chambers, thoroughly separating the lighter particles and carrying them off in the overflow at the lower end, and leaving the clean sand in the box. The length and inclination of the flume and the quantity of water used, are carefully adjusted to give a velocity just sufficient to carry the sand along without clogging, and to scour the sand grains free from loam and clay. After one of the sand boxes is nearly filled, the head gate is thrown over and the water and sand diverted into the other box. The washed sand from the former box is then shoveled by hand into wagons and hauled by teams ¾ mile to storage bins at the end of a tramway. Here it is loaded, as required, into dump cars hauled by mules to a small storage bin at the concrete mixer. The sand-washing plant has a capacity of about 100 cu. yd. a day, and the cost of operation, excluding the digging and expensive hauling, is about 10 cents per yard.



Arrangement of Large Concrete Blocks in Dam.



Concrete Plant and Cement Storage.

Granite for the concrete is secured from two quarries about a mile above the dam, and is transported in 1-yd. cars drawn by mules and delivered to a platform over a jaw crusher having a capacity of 100 cu. yd. in 10 hours. The product of the crusher is raised in ordinary bucket elevators to cylinder screens, which discharge it to storage bins delivering by gravity to the mixing platform. All of the product which passes through a 2½-in. screen and is rejected by a ½-in. screen is used for the concrete. That which passes through the ½-in. mesh is stored in a separate bin and is mixed with the concrete sand, forming about 10 per cent. of the total volume of the latter. The cut stone for the spillway steps and dam crest is secured from a third quarry, 2 miles above the dam, and is hauled about one mile in wagons from which it is transferred to flat cars on the tramway.

Cement is delivered by rail at Buena Vista, Va., and hauled by a local steam tramway to within about ¾-mile of the top of the mountain, where storage is provided for only two or three car loads. From this point it is hauled, as fast as received, in wagons drawn by 2 to 6 horses, to the top of the mountain and thence five miles down the mountain, descending about 1,800 ft., to the dam. This is a very costly part of the work, the road being exceedingly rough; and both wagons and teams give out after a relatively short service. A considerable number of horses and mules have been lost by rupture and other accidents. At the dam the cement is stored in houses having a capacity for about 30 carloads; a two weeks' supply being kept on hand.

On mixing the concrete the sand is first dropped from the storage bin to an inclined chute, filling the chute up to a mark on the side which indicates 6 cu. ft. The cement is then added by hand, three bags per batch, and finally enough broken stone, 12 cu. ft., is discharged through the gate in the storage bin to give the required total quantity. The contents of the chute are then discharged through a gate to a Ransome concrete mixer at a low level, which delivers to 1⅓-yd. bottom-flap steel buckets on flat cars. These are shoved by hand on a 30-in. track carried from end to end of the dam on a trestle falsework 400 ft. long, parallel with the upstream face and 40 ft. below the crest of the dam. The buckets are handled and emptied into the concrete molds by four boom derricks seated on a trestle falsework and cribwork 20 ft. above the track. The derricks are rigged with wire guys and tackles and are operated with hoisting engines provided with swinging gear.

The shape, dimensions and location of the concrete block molds are determined by the resident engineer who locates them so that each block shall set at least six days before any adjacent block is made, and so that there will be no continuous horizontal or vertical joints through the dam, or no unbroken vertical face more than 10 ft. high between adjacent blocks. The maximum dimensions of the blocks are 12 ft. in height and 15 ft. in length. The average size is about 50 cu. yd., the essential requirement being that no block must be larger than can be completed on the day in which it is commenced. All of the molds are made with unplaned lumber well smeared with soft soap. An exception to this is made for the face blocks, the exposed surfaces of which are made against planed boards 1 in. thick. All boards have square edges and the cracks between them are calked, if necessary, with oakum. The keying grooves in the faces of the blocks are made with cores formed of three 4x4-in. timbers. When these are removed, the grooves and strips 6 in. wide on each side are thoroughly painted with a thin 1:1 mixture of Portland cement and fine slaked lime, applied and well rubbed in with a brush.

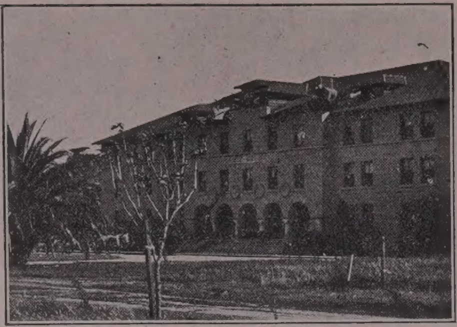
The sides of the forms are made of 1-in. horizontal boards about 10 in. wide, tacked up loosely to vertical 4x4-in. posts, to which are tacked 4x4 or 4x6-in. horizontal timbers about 4 ft. apart, braced by inclined struts having their feet wedged in sockets picked out of the concrete. The opposite faces of the molds are not connected by interior ties because the latter would obstruct the space necessary for laying the cyclopean stone; therefore on the upstream and downstream faces of the dam the outer horizontal timbers are secured by telegraph wires passing through the face boards and secured to anchors made by bedding loops of wire in the top of the concrete blocks previously completed. This device has been found very simple, efficient and economical. The top of each block is finished in steps. The blocks being of irregular sizes and shapes must be set up independently, but this arrangement facilitates convenient construction as the boards and timbers for three sides of a block may be of any convenient length, the ends projecting beyond the corners of the block, except for the fourth side, where the pieces have to be cut to match the finished face.

In building the foundations of the dam, the excavation was carried to sound rock and its surface was dressed, cleaned and washed as carefully as practicable. After the forms had been set for a block, a few buckets of 1:1 cement grout were poured over the surface of the rock and thoroughly rubbed in with wire brooms. Upon this grout a 6-in. layer of concrete so wet that men would sink in it up to their ankles, or even to their knees in deeper holes, is spread.

Roughly rectangular quarry stones weighing from 150 to 6,000 lb., the limit of the derrick capacity, are slowly lowered into the form for a block and while suspended are thoroughly wet and washed by a hose. After being released from the tackles, they are twisted and barred until thoroughly bedded in the concrete and until it is believed that no empty spaces remained under the bottoms. Special care is taken to avoid any hollow places on the lower surface of the stone in which air might be trapped. As many large stones as possible are set in the form; around these large stones and in the spaces between them concrete is rammed, spawls being used to fill up large spaces and save concrete. Care is taken to avoid as much as possible the formation of layers or coursing. When the form is thus nearly filled the top is finished off in horizontal longitudinal steps of about 10-in. rise. It is desired, in this class of masonry, to include as much large stone as possible in order to increase the density and cheapen the cost. Using stones of 1 to 2 cu. yd. each, fairly regular in form, it is possible to reach a limit of about 40 per cent. stone and 60 per cent. concrete in the aggregate; with small stones set by hand the proportion runs as low as 12 per cent.

Work was commenced in July, 1904, and the concrete is now somewhat over half finished. The original amount of the contract was $103,000, which sum will be somewhat increased by changes developed in the work and by the substitution of Portland cement for natural cement in all parts of the work.

The dam was designed by Mr. James H. Fuertes, consulting engineer. Mr. H. L. Shaner, city engineer of Lynchburg, is chief engineer, Mr. P. B. Winfree is resident engineer, and Mr. Chauncey G. Williams is the contractor.



Roble Hall after Earthquake.

The Effect of the Earthquake at Stanford University, Cal.

By Prof. Charles D. Marx, M. Am. Soc. C. E.

The earthquake shock at 5:13 on the morning of April 18 was caused by a lateral displacement along the line of a fault running in a northwesterly direction about 5 miles southwest of the University. This lateral displacement seems to be as much as 3 or 4 ft. in some places. No marked vertical motion has been observed aside from slides, so far as I know. Dr. Brunner, of the geological department of the University, placed a number of parties in the field and is making a careful study of the problem.

Our examining committee, consisting of Prof. Charles B. Wing, acting as structural engineer, Prof. William F. Durand, as mechanical engineer, Prof. Arthur B. Clark and Prof. Charles E. Hodges as architects and myself as chairman, made its investigations of the buildings at the University, on April 19 and 20. This examination did not cover the memorial church, the arch, the museum, the new library and the gymnasium. The last two buildings were unfinished. The committee's report reads as follows:

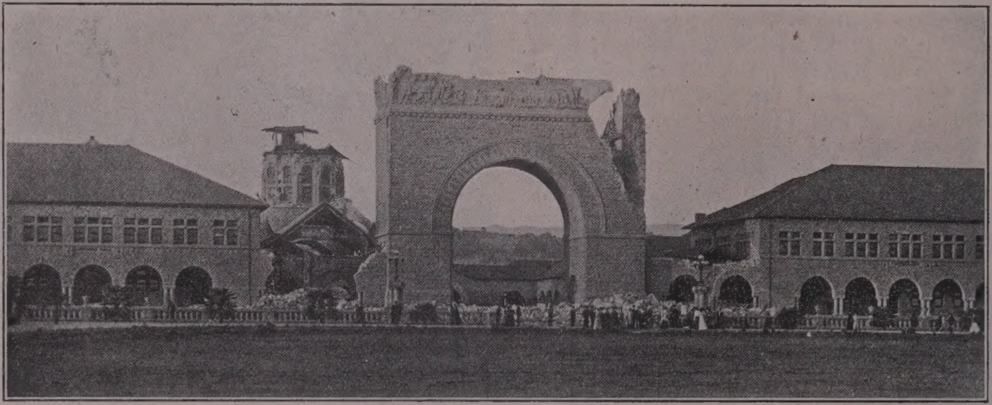
"After a careful examination of the buildings used for university purposes, including Roble and Encina Halls, we find that the damage from the recent earthquake is much less than was anticipated.

"The buildings of the inner quadrangle, the one-story buildings of the outer quadrangle (with one exception), the Zoology Building, the Physiology Building, the Assembly Hall, the Library, the old Engineering Building, the Machine Shop, the Foundry, and the Mechanical Laboratory are substantially intact and can be used after a few minor repairs.

"The four corner two-story buildings and the small one-story Physics Building of the outer quadrangle, the Forge Shop, the Woodworking Shop and the Chemistry Building will require partial rebuilding of some of the walls.

"In Encina Hall the south walls of the east and west wings will require partial reconstruction; also those portions injured by the two falling stone chimneys. The fall of one of the chimneys, which tore through the floors to the basement, caused the death of one student. Aside from the damage noted above the building as a whole is uninjured and perfectly safe.

"The damage to Roble Hall is confined to the two holes torn in the floors by the falling chimneys. The remainder of the building shows practically no evidence of having passed through an earthquake.

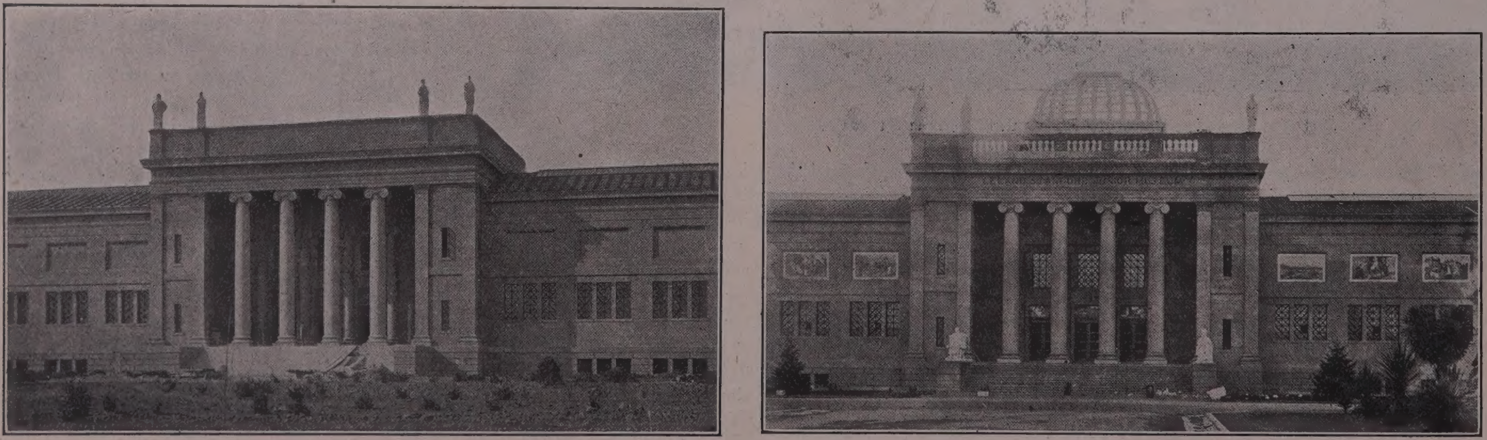


Effect of Earthquake on the Memorial Arch.

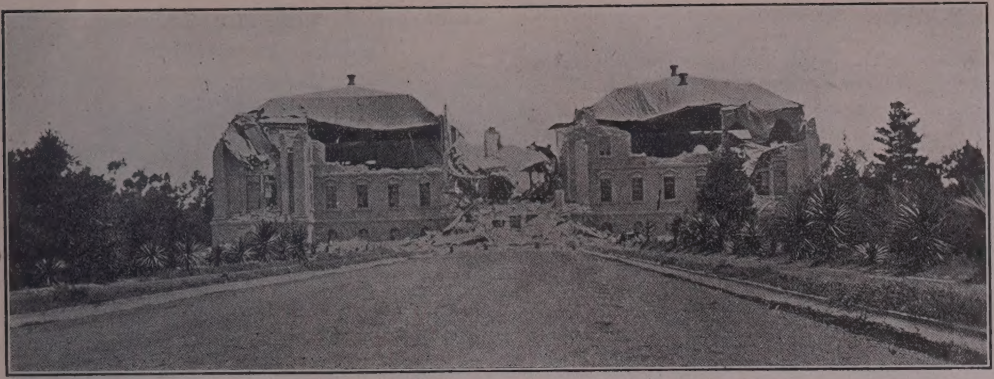
"In the opinion of the committee, such of the buildings mentioned above as are necessary for carrying on the university work can easily be made ready for occupancy and safe use in time for the opening of the University on Aug. 23.

"Our full and detailed examination of the buildings from foundation to roof shows that the actual damage to their stability is less than might be inferred from external appearances."

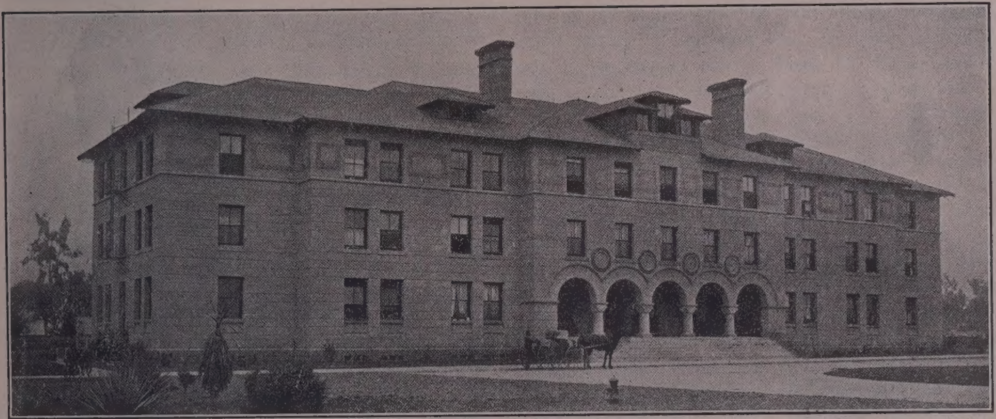
The buildings of the inner quadrangle are one-story masonry structures with stone facing and



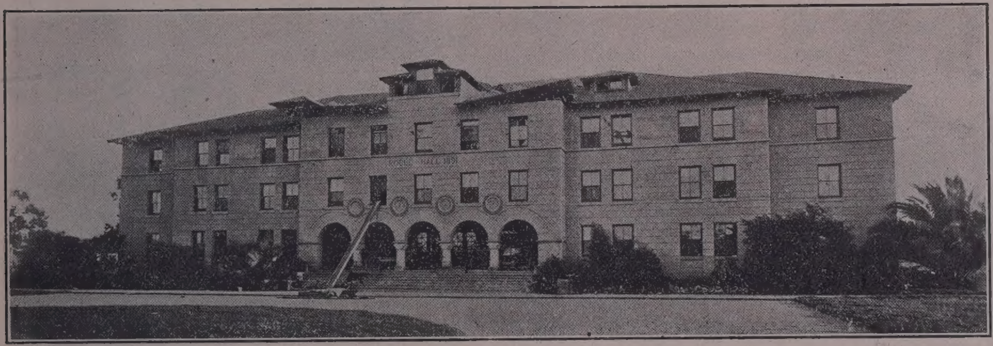
The Main Building of the Stanford Museum as It Appeared Just after Completion and after the Earthquake.



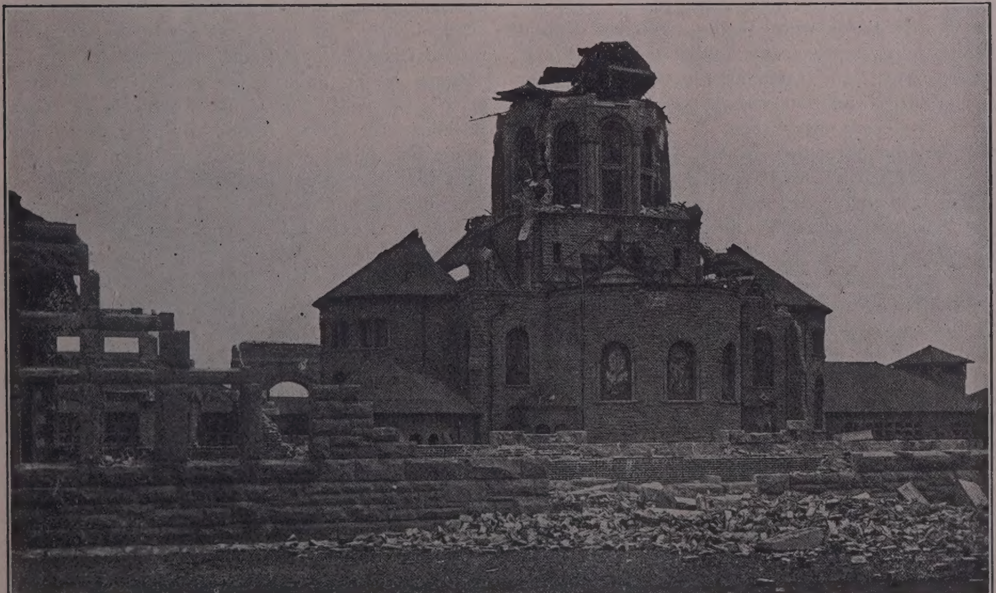
Front View of Gymnasium; the Central Dome was Destroyed.



Roble Hall, as It Appeared Just After Completion.



The Effect of the Earthquake on Roble Hall.



Rear View of the Memorial Church.

rubble backing. They were finished about fifteen years ago and stand substantially uninjured. The buildings of the outer quadrangle are mostly two-story structures. The walls are of brick with sandstone facing. Most of these buildings are of recent construction and they have suffered considerably. The Zoology Building, which has steel roof trusses, has suffered least of the structures in the outer quadrangle. Most of the other two-story buildings in this quadrangle have no roof trusses, the inclined rafters resting on wall plates. The horizontal thrust has shoved the walls out of plumb at the top in a number of cases. Why it did not do so in all is a hard question to answer.

The tower (which is not a steel skeleton structure) of the church broke through the roof of the latter and its weight also carried down part of the concrete floor of the church in the center. The damage to the church, aside from this, is not so great as supposed at first. The main walls show no serious cracks and most of the mosaics in the interior are therefore uninjured. Only three of the stained glass windows in the apse are slightly damaged. Since the gable wall on the northeast end of the church fell outward the organ is uninjured.

The arch was merely a large masonry block, not tied in any way; it was left in the condition shown in the photograph.

Encina Hall, the boys' dormitory, is of the same construction as the buildings of the inner quadrangle, and was built at the same time. This is the highest building we have here. It is absolutely uninjured save for the damage done by the falling chimneys crushing through the floors and the cracking of the rear walls of the two end wings. Encina Hall is well built and has roof trusses of timber, in this case, holding the walls well together. Of course the end walls which cracked were parallel with those trusses.

Roble Hall, the girls' dormitory, is a monolithic concrete building without steel reinforcement. Two falling chimneys knocked holes through the floors; no other damage was done. I have been told that these concrete chimneys were put on after the building was finished. The steel rods to be placed in these chimneys had been delivered at the University and it was always assumed that they had been put in place. Had such been the case the building would stand absolutely uninjured.

The central part of the Museum is of monolithic concrete construction with twisted steel rods only in the floor system. The side wings and rear parts were added later; these have brick walls with a plaster coating. As can be seen from the photographs, these have suffered considerably, while the main part of the Museum stands uninjured. The mosaics on the outside walls are not cracked.

The new Library, which was being constructed, had its walls, built of brick with stone facing, badly shaken down. The central dome, carried on steel columns and built of the same kind of masonry, is as good as the day it was built. Not a pane of glass in the skylight was cracked and a wooden ladder on the outside of the dome lies there undisturbed.

The Gymnasium was a large pile of masonry. Its central dome was carried on a light flimsy structural steel truss and is the only dome which has come down so far as I know. The main roof trusses over the two ends of the building are of steel and have held the walls well together.

While in San Francisco recently I did not have a chance to examine carefully any of the steel structures still standing. It is undoubtedly true, as stated in The Engineering Record, that the structural steel building has come out of the trials victorious. Still, as I look at our Encina Hall and some of the other buildings, I think that intelligent design and good workmanship are the factors of most importance in designing structures of any kind. In all probability brick walls laid in good cement mortar can be made as monolithic as concrete walls. That these latter need no steel in the walls to resist shock has been shown in the case of Roble Hall and the Museum. That masonry structures built around structural steel framing can be made to resist the shock of earthquake is shown by the dome of our Library and by the many steel buildings standing in San Francisco.

The Cause of the Earthquake.

Prof. W. M. Davis, professor of geology of Harvard University, states that there is not the slightest indication that the San Francisco earthquake was in any way due to volcanic action. In an interesting article written by him for the New York *Evening Sun* he states that while earthquakes are common in the districts of active volcanoes, they are more common in non-volcanic regions of disturbed or mountainous structure, where the deformation of the earth's crust seems to be still in slow progress. Even in islands so largely volcanic as those of the Japanese Archipelago there is good reason for thinking that many of the numerous shocks there recorded are due to massive crustal movements and not to volcanic action.

In so far as California earthquakes are concerned, the case is stated by Prof. Davis in brief as follows: "Our Pacific coast is not a volcanic district, although many extinct volcanoes occur in the northern Sierra Nevada, and vast floods of lava have been poured out in a past geological age over the basin of the Columbia River. The Coast Range is largely made of stratified rocks. The strata, originally deposited beneath sea level in nearly horizontal layers, now stand above sea level, tilted, bent and broken into the deformed structures characteristic of mountain ranges the world over.

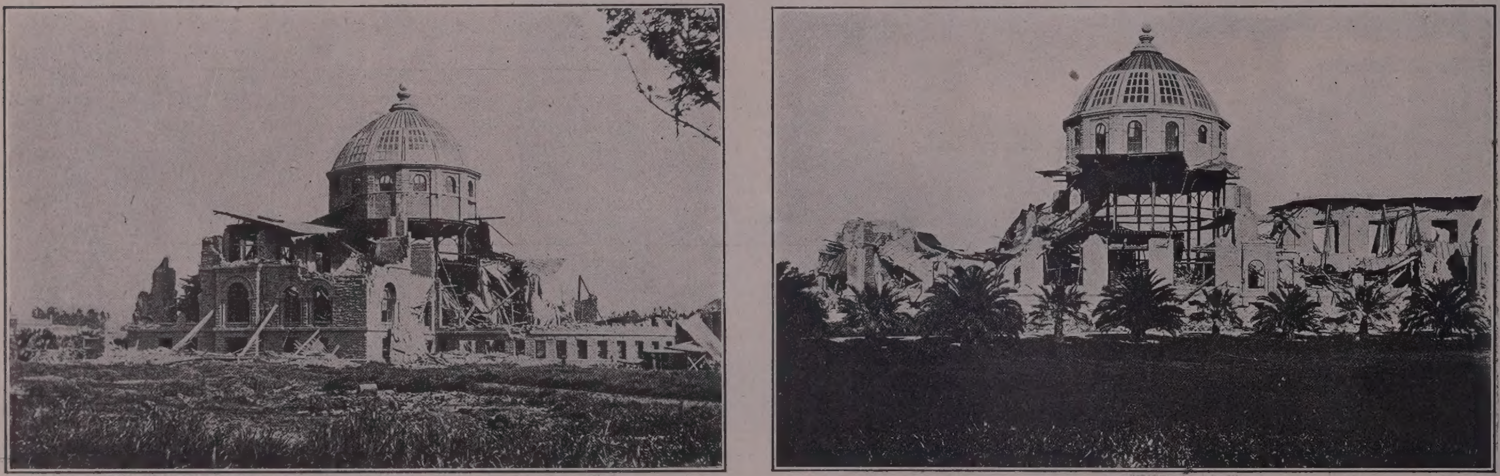
"All the movements by which the strata of the Coast Range have been deformed must, according to every reasonable analogy, have been accompanied by snaps and tremors, as the rocks were bent and broken. The numerous earthquakes already recorded in California, in the short period during which it has been known to civilized mankind, are the surface manifestations of the later stages of these underground movements, and the recent San Francisco earthquake is simply the very latest member of a long series of disturbances.

"The peninsula of San Francisco consists essentially of two great blocks of earth crust, each one somewhat tilted, and the two separated by a long and profound fracture, trending north-northwest and south-southeast, the northeastern block having been uplifted some 7,000 ft. with respect to the southwestern. This displacement is not ancient in the measures of geological time, yet took place so long ago, humanly speaking, that the blocks have been since then greatly worn down and elaborately carved by valley-cutting streams. It requires the trained imagination of the geologist to reconstruct the original contours of the blocks, so dilapidated are they now, so thoroughly dissected, so far fallen into ruin. Whether the recent earthquake was in any way associated with a renewal of movement on this ancient block-fracture, it is impossible at present to say anything definite. It is, however. important to note that the area of greatest destruction extends through a belt which lies roughly parallel to the trend of the Coast Range, and this fact makes it pretty certain that the earthquake is of the mountain-fracture class, and that it sprang from some one of the structural lines along which the mountains there have long been in process of deformation.

"Any one is free to suppose," Prof. Davis says, "if he wishes, that the tensions in the rocks of the Coast Range were snapped by the tremors from Vesuvius, but it must be remembered that the tremors from Vesuvius are much weaker than those which spread away from a first-class mountain-fracture earthquake; that the tensions under the Coast Range must have been accumulating for years past, and that during this period various tremors, much stronger than those lately caused by Vesuvius, have passed through the earth. If there were really a distinct causal relation between volcanic outbursts in one part of the world and earthquake shocks in another part, such a relation would pretty surely have been long since established.

"The San Francisco shock was recorded in Europe. The term earthquake is, therefore, more fitting in a literal sense than was imagined when the word was coined. Furthermore, the high speed with which earthquake tremors travel through the earth confirms the evidence of other kinds as to the greater density and close texture of the earth's interior. Hence the idea of anything more than a connection by tremors between Vesuvius and San Francisco is groundless, and the tremors of this kind are extremely faint when they have traveled 5,000 miles or more."

The Zoelly Steam Turbine has given good service on a 13-knot tramp steamer built by Messrs. Howaldt, of Kiel. This installation, of 1,000 b.h.p., was made by Escher, Wyss & Co., of Zurich, and consisted of two turbines driving twin screws. The steam consumption was reported to be 14 lb. per horse power by Mr. E. A. Speakman.



Rear and Front Views of the New Library at Leland Stanford, Jr., University.

Comments of Californian Engineers on the Earthquake and Fire.

From Prof. Frank Soulé, Dean of the College of Civil Engineering, University of California.

The recent great earthquake, and the only one of the series that caused any serious injury, began on the morning of April 18 at 5:13:38, standard time of the 120th meridian. The duration of the severe part of the "quake" was 38 seconds, but the vibrations of the earth's crust continued for over a minute, and were followed at short intervals by many others of slight intensity. There were fourteen such recorded during the remainder of April 18th, and more than forty have occurred up to the present time (April 30); none severe.

The motion in the first great shock was at first from east to west and finally from southeast to northwest, the displacement as measured by seismographs being about $\frac{3}{4}$ in. The Duplex instrument at the University of California gives a graphical representation showing a large, somewhat tortuous, closed curve, made during the vibrations, and indicates that the motions were from all directions at different moments, like those of the surface of a cake of jelly resting upon a plate, when the latter is severely struck. The severity of the first shock is estimated at 9 in the Rossi-Forel scale, by our seismic authorities.

The writer has visited and inspected some twenty-five of the principal large buildings and structures of the most modern type, as well as many others, and has ascertained the effects of the earthquake shock upon them previous to their attack by fire. In every case where the structure was of Class A, steel-frame, with first-class foundations, either upon good ground "in natural place" (as with the Claus Spreckels or Call Building, the James Flood Building, etc.) no appreciable injury was done, and but for the conflagration they would now be in service. The same can be said of that class of superstructures resting upon excellent foundations of piles driven through made ground to a solid sub-stratum, as exemplified by the new Merchants' Exchange, the Mills Building, the Kohl, formerly the Hayward, etc.

In the case of those Class A buildings founded on made soil, such as filled in sand, mud and the like, the walls have been cracked and injured to a considerable extent, requiring in some instances large expense for repairs. A notable example is the U. S. Post Office at the corner of Seventh and Mission Sts. This is a handsome, well-designed and strongly built structure of the new type, three stories in height. Had it been raised upon an excellent foundation it would undoubtedly have passed through the "temblor" unharmed; but unfortunately for it, the site is

Brick Building in Oakland

Hardware Warehouse in San Francisco.

a sand lot, across one corner of which formerly ran a branch of Mission Creek, underlaid by a deposit of mud and silt. The lot had long been filled into grade with sand; and the Government agents, after much adverse criticism of the sub-soil, endeavored to unify and strengthen the "bed of foundation" by the liberal use of steel-concrete piers. The granite walls on every side of the Post Office are badly cracked from the third story under the roof to the foundations; while the walls, the marble veneer, the partitions and the fireproofing on the interior are badly shattered and thrown to the floor in great quantities. The sidewalks around the building are separated from it and each other, and upon the Mission St. side have, in places, sunk 3 ft. below grade, indicating very plainly a defective support.

The total damage to this building is estimated at $100,000, and is to be attributed to the defective foundation, the filled-in area, but not to the weakness of the superstructure; that in itself is strong and excellent.

The water front and sea wall of San Francisco lie far outside the old shore line of the harbor; and the intervening mud-flats and silt bottom between were at an early day in the history of the city filled-in with rubbish and sand. Upon this material, sometimes using long piling, and at other times platforms and grillages of timber, a large number of the commercial and wholesale houses were erected. This "made ground" was greatly disturbed and rolled into waves by the earthquake; but wherever the piling under the brick or stone walls had been heavy, deep and well done there resulted little injury to the masonry.

The Union Ferry depot at the foot of Market St. is a modern steel frame building of great length and width; and has a very high tower at its middle on the landward side. The front and ends of the depot and the lower two-thirds of the tower are faced with Colusa sandstone. The building is founded upon concrete arches and piers resting upon timber grillages supported by wooden piles driven 80 ft. into the silt, blue clay and yellow clay successively of the bay's bottom. There are seventy large piers with sixty piles each that carry the heaviest landward part of the depot; thirty small piers with nine piles each under the light bay side, and 250 piles carrying the tower, which partly rests upon the sea wall running beneath it. The foundation was regarded as heavy, substantial and sufficient, even in this bay mud. The high tower was badly shaken and lost a part of its stone veneer which, falling upon the roof the depot, broke through it to the second story, or floor beneath it, and caused the greatest part of the damage to the building. The tower will probably be taken down and reconstructed. The southeastern end of the wall of the depot, the part first struck by the earthquake, was also cracked and in part thrown down, and some cracks appear in other portions of the structure, but no serious damage appears, the floors are apparently level and the depot is in constant daily use.

This case of a heavy structure resting entirely upon concrete piers some 30 ft. above their bases on piles in mud, and not reaching hard, solid bottom, seems a crucial test for the modern steel-frame structure, and indicates to the writer that the engineer and architect can build sufficiently strongly to defy any earthquake that is likely to come.

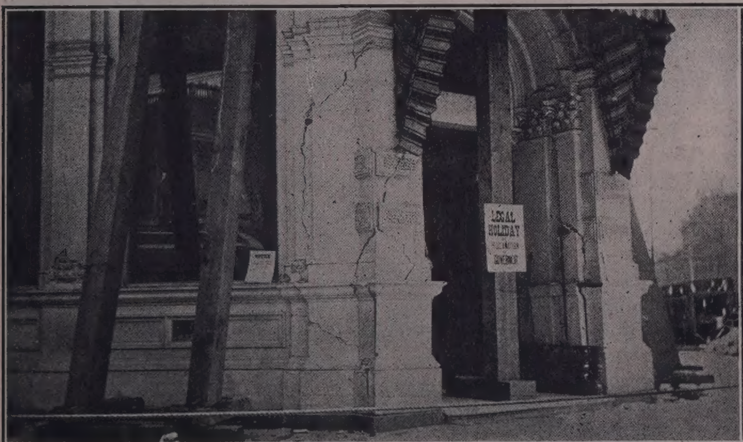
Other brick or stone buildings erected upon some of this filled-in area, but having weak foundations or thin walls were badly cracked, and in some instances, completely wrecked.

The Palace Hotel, an immense structure of brick, seven stories in height, built nearly thirty years ago, and therefore not in the latest type, endured successfully the severe shock, as it had many a lighter one in past years; but was gutted by the fire. It was founded in a deep excavation in wet sand "in place," and was constructed with very thick walls of brick. It had been regarded as both earthquake and fire proof.

The San Francisco sea wall was built in sections a thousand feet or so in length. It was constructed, with the exception of the length under the Union Ferry, by excavating the soft mud of the bay's bottom to a depth of 34 ft. and thus forming a long, broad trough in the stiff mud beneath; then filling this up to the desired level above high water with heavy random stone. Between this wall and the main land sand was dumped in to the same level. The wharves, with timber and latterly concrete or metal piling, have been established along its exterior face. This sea wall has been shaken by the "quake," and at some points has been changed in level; but apparently has suffered no serious injury.

Substantially built structures of wood resting upon good foundations in either natural or made ground have suffered no injury save as to chimneys and plastering, but flimsily built houses on poor foundations have collapsed, or been completely wrecked. The most remarkable instance of this kind is that of the Valencia Hotel, at the upper end of that street. It stood upon a deep filling of mud and sand. During the shake it dropped suddenly many feet into the earth, one side much deeper than the other, and doubled together like a jack-knife, the upper stories lying upon the lower. The guests in the higher rooms escaped into the street, but twenty-five in the lower were buried alive.

As the result of study of the effects of this earthquake, the writer has the firm conviction that (1) the modern Class A steel-framed structure having a proper foundation will endure without appreciable injury any earthquake that is likely to



Brick Building in Oakland.

The Sloane Building, San Francisco.

occur. (2) That a strongly-built wooden house on a good foundation bed will suffer little in any earthquake. (3) That wrought-iron shutters on the exterior of the windows of the great Class A steel-framed buildings in San Francisco, if operated by engineers and power, would have prevented the destruction by fire of a large number of her best designed and practically earthquake-proof structures.

From Ralph Warner Hart, San Francisco.

You may be interested to know that the warehouse I have under construction here using Kahn bars is up two stories, the third floor slab being finished four days before the earthquake, and that not a crack of any kind is visible in the columns of the first story or the beams and slabs of the second floor. I made as careful an examination as possible, from the floor, and am more than delighted with its condition.

Because of the influence of the bricklayers' union, the city authorities refused us a permit for this building until we conceded brick walls. These walls are so badly cracked that probably one-third of same must be rebuilt. If we had had reinforced concrete outside walls I am confident that the earthquake would have done no damage whatever to this building.

From August Ziesing, President American Bridge Co.

I have just received a letter from our representative in San Francisco in which he advises me that the only buildings that are still standing in the burned portion of the city are the more recently built ones, including the Fairmont Hotel, the Flood Building, the Crocker Building, Call Building, Mutual Savings Bank Building, Union Trust Building, Shreve Building, Mills Building, St. Francis Hotel, Hayward Building, and the Merchants' Exchange, all steel buildings. Of course, these were all considerably damaged by earthquake and fire, but had the fire not occurred, the damage would have been only such as could have been easily repaired without any very great outlay of money. The fact that all of these buildings were surrounded by blocks of wooden structures, made the fireproofing of them of little service, except that it no doubt delayed their destruction. Should the city be rebuilt under strict fire regulations; that is, with all fireproof buildings, a fire of sufficient proportions to destroy a modern steel building can never again occur.

From John B. Leonard, San Francisco.

There were no reinforced buildings in San Francisco, the nearest approach being intermediate beams supported on steel girders and columns in one or two of the buildings. There were several buildings which had reinforced slab construction and one or two that had steel columns fireproofed with concrete. So far as I have been able to observe, all of the concrete construction in San Francisco has come through in practically a perfect condition, but it is impossible even at the present time (April 28), to gain access to the buildings in order to make a minute examination. In the outlying districts, there were several reinforced buildings and reports from these, together with such newspaper accounts as have come to hand, indicate that they are sound.

From Arthur L. Adams, San Francisco.

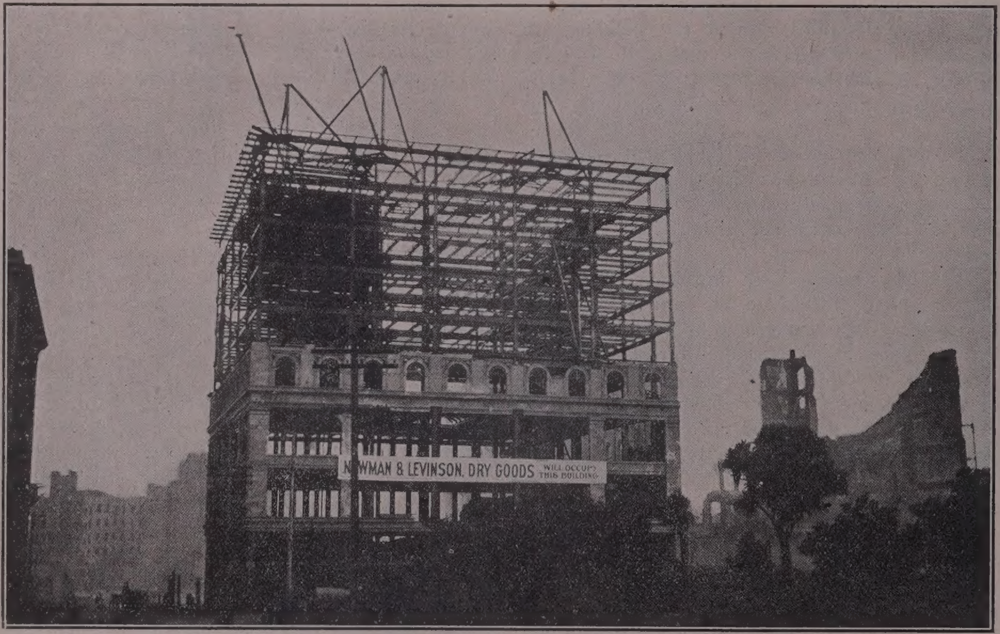
Present opinion as to the degree of injury wrought by the recent earthquake must be subject to modification upon more exhaustive examination than it has yet been possible to make. The general impression among engineers, in which I concur, is to the effect that first-class construction was not very materially injured by the earthquake shock, while bonded masonry, particularly when laid up in lime mortar, suffered severely. Wooden houses were, of course, little injured save for loss of chimneys and cracking of plaster. First-rate brick and stone construction suffered a little injury by way of cracks and an occasional throwing down of balustrades and cornices. Tall steel frame buildings were apparently not injured save for some damage to plastering with occasional displacement of marble waistcoting or other stone finishing.

Of the total destruction in San Francisco, an insignificant part can be attributed to the earthquake, but the fire has wrought fearful havoc. And I am convinced that, contrary to the opinion of many, there are very few buildings in the city in which the salvage will amount to little if any more than the value of the steel frames. To this there are, of course several notable exceptions which it is not necessary at this time to enumerate.

The San Francisco Association of Members of the American Society of Civil Engineers, realizing the unusual opportunity here afforded for studying the effect of the earthquake upon different types of building construction, as well as on sewer and water works structures, has already appointed committees to investigate and report upon these questions.

From Maurice C. Couchot, Alameda.

Among the Class B buildings in San Francisco one that deserves special mention is the Folger Building, which had brick walls, and some floors of reinforced concrete and others of wood. This building is absolutely intact with not a pane of glass broken. It rested on a pile foundation and the streets on both sides of it sunk 5 ft. bodily. The architect of the building is to be highly complimented on the showing.



Butler Building, San Francisco, Practically Intact.

It would appear at this writing that cast-iron columns were generally ruined by the fire. It is probable, however, that some of their connections were broken by the earthquake so that when the fire came these places gave way and wrecked the structure in the manner typified in the Sloane Building. This structure had concrete floors and a terra-cotta front, and was filled with furniture, which raised the temperature to a high point when it burned. The building was apparently intact after the earthquake, but was completely ruined by the fire. The appearance of its entrance is shown in an accompanying illustration. It is interesting to compare this picture with the view of an Oakland bank entrance; this had brick piers plastered.

Two more pictures show the effect of the earthquake on a brick building in Oakland, and the effect of both earthquake and fire on a brick hardware warehouse at the corner of Baker and Hamilton Streets, San Francisco.

In the picture showing the Palace Hotel, Monadnock, Examiner and Call Buildings, the angle at which the camera was held was responsible for the apparent tilting of the building. The Palace Hotel was built of good brickwork in 1874. It was proof against earthquake and would have been proof against fire under any ordinary conditions. The Monadnock Building illustrates the condition of the lightest possible steel frame and veneer wall construction. The Examiner Building was a Class B structure and was entirely destroyed. The Call Building was the best example in the city of well-designed steel frame construction with concrete floors. The companion picture shows a lofty steel-cage frame of a building in course of construction, with the ruins of a Class B building in the foreground. The picture of the condition of the unfinished Butler Building, practically intact after the earthquake and fire is impressive when compared with the ruins to the right of it. The view of the houses on Van Ness Ave. is interesting, as showing the effect of the earthquake at a point where the street surface dropped 5 ft.

From the Expanded Metal & Corrugated Bar Co., St. Louis.

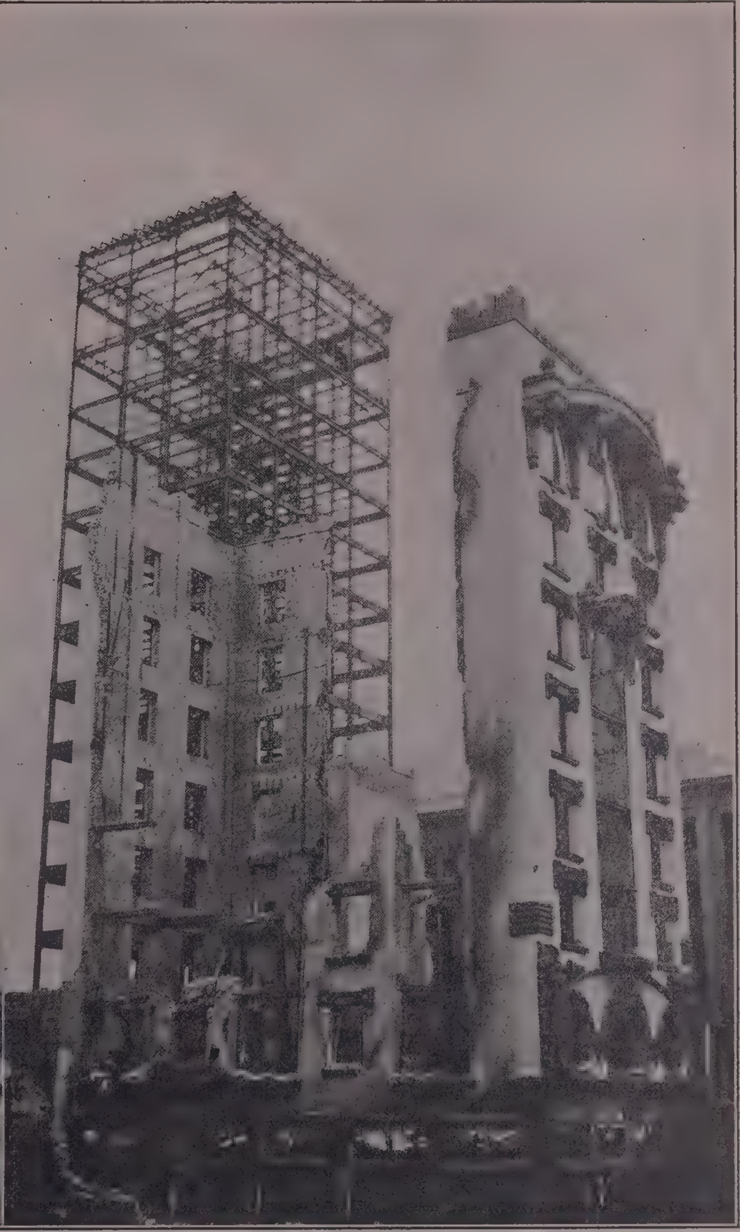
Our San Francisco representative, Mr. John B. Leonard, M. Am. Soc. C. E., wires us that reinforced concrete construction made a wonderfully satisfactory showing in the earthquake and fire catastrophe in San Francisco. Our Los Angeles representative, Mr. Carl Leonard, the most prominent contractor in Southern California, who has been to San Francisco on an inspection tour, also wires us to the same effect, confirming Mr. J. B. Leonard's report.

Mr. Theodore Starrett, president of the Thompson-Starrett Co., New York, received a telegram from a representative at San Francisco on April 25, reading: "Reconstruction commenced. Monadnock Building renting offices for occupancy in ten days. Call Building to be occupied next week. Hayward Building uninjured and doing business." The Monadnock Building was just being finished when the earthquake happened. The Hayward Building is about ten stories high and was built very carefully, the trimmings being of sheet metal and the exposed windows fitted with wired glass. The Call Building, otherwise known as the Spreckels Building, was described in this journal on April 9 and 16, 1898.

The Saving of the Western Electric Building at San Francisco.

The four-story brick building in which the San Francisco office of the Western Electric Co. is located was one of the few buildings in the business district of the city exposed to the recent earthquake and fire that escaped with practically no damage. A brick cornice around the top of the building was more or less shaken down by the earthquake, which also cracked the brick walls carrying a 50,000-gal. water tank above the roof, one corner of a pent-house and a brick smokestack connected with the building. The fire checked much of the wire glass with which the windows are glazed and in some places nearly melted the glass but the windows throughout the building remained intact. It also melted the putty around the window panes, blistered some of the furniture in the building and burned a small hole in the vicinity of the crack in the walls of the pent-house. The metal sheathing on the fire doors on one side of the building was melted off and a switchboard cable along the windows on another side was scorched. With the exception of these very minor damages, the building is intact and the business of the Western Electric Co., was interrupted only during the fire.

Palace Hotel, Monadnock, Examiner and Call Buildings.



Steel-Cage Building under Construction; Class B Building in Front.

The building faces on Folsom St., near Hawthorne St. It is less than a quarter mile from the Palace Hotel, which was completely gutted by the fire, and is close to what was the most congested part of Market St. and the business district of the city. This district was completely wiped out, although many of the structures in it were not exposed to any more severe fire conditions than those surrounding the building of the Western Electric Co. The fire burned out every structure in its immediate vicinity, passing along the rear and one side of the building on the first day of the fire, and then, when the wind changed on the second day, the fire swept along the front and other side of the building.

The building was built according to the requirements of the Factory Mutual Fire Insurance Companies of Massachusetts for factory buildings of slow-burning mill construction. It was completed in October of last year and is remarkable in that it was probably the only building in San Francisco built strictly according to true mill-construction requirements, although timber has always been comparatively cheap and abundant in that section of the country. The building covers a site 146 x 158 ft. in plan, facing on an alley and two streets. It is divided by a fire wall into two practically separate structures, one 50 x 158 ft. in plan, with its front on Folsom St. and its rear on a street parallel to Folsom St., its exposed side being on the alley; the other section is 96 x 118 ft. in plan and has its front on Folsom St., with its exposed side on an open lot, 50 ft. wide. A space of 40 x 96 ft., thus remains open at one corner of the site at the rear of the 96 x 118-ft. section of the building, and is utilized as a shipping and teaming yard.

The walls of the building are brick laid in cement mortar and rest on spread concrete footings. The thickness of the outside walls is not uniform on account of a number of piers required by unusually large window openings. The thickness of the brick fire wall varies from 21 in. in the basement to 12 in. at the roof. All staircases, elevator shafts and other openings extending from floor to floor are built in brick shafts which entirely separate them from the remainder of the building. The framing of the floors is divided into 14x16-ft. panels, the longer spans extending transversely across the building. Each floor is carried by 8x16-in. girders of Douglas fir laid transversely across the building. These girders are placed in pairs, one pair on each side of each floor panel, and are carried by the brick walls of the building, and by wooden columns carried up from footings in the basement. The columns are placed in regular transverse and longitudinal rows, one column at each corner of the floor panels. They are 12x12-in. timbers in the first and second, and 10x10-in. timbers in the third and fourth stories. The ends of the 8x16-in. floor girders carried by the walls are extended 8 in. into the latter. The wall ends of each pair of girders rest on a 14¼x18x1-in. cast-iron bearing plate, set horizontally in the brickwork of the wall. A 4-in. lug is cast on the back edge of this plate and anchors the latter in the brickwork. A 1-in. lug, cast on the front edge of the plate, sets in a notch in the lower side of the girders and anchors them to the plate. The ends of the girders carried by the columns rest on cast-iron pintels, in one piece, which set on and are anchored to the columns. Over the 8x16-in. girders are placed 1⅞x6-in. plank, on edge. These plank are laid transversely to the girders and are spiked together and toe-nailed to the girders, forming a tight floor 6 in. thick. A finished floor, consisting of 1⅛-in. matched maple, is laid over this tight floor. All of the main roof girders are 10x14-in. Douglas fir timbers. Over these girders are 1⅞x4-in. plank laid as in the floors. The roof covering consists of tar and gravel. The roof contains a number of skylights which have galvanized-iron flashings and are glazed with wire glass.

The rear of the 50x158-ft. section of the building is carried up to form a small pent-house 14x50 ft. in plan, which is used for drafting. The brick cornice, which was shaken down, was corbeled out from the side walls of the building and extended around the latter at the top. The 50,000-gal. water tank is carried 25 ft. above the roof of the building by a brick wall in the shape of a T, which is formed at the intersection of the brick fire wall separating the two sections of the building and the rear wall along the 96x118-ft. section. One branch of this T wall above the roof was cracked by the earthquake and the tank may have to be taken down and the wall rebuilt. The tank was built on the brick walls instead of a steel frame, in order to provide to some extent for earthquake shocks. The brick stack, which was cracked, is 4½ ft. square, and is built in the rear inside corner of the 50x158-ft. section of the building, but is separate from the walls of the latter. The stack serves a mechanical plant in the basement. The portion of it above the roof may have to be partially rebuilt.

The building was constructed with the expectation that an addition will at some time be built on the open lot on the side distant from the alley, so there are no windows on that side. On the side next the alley and on the front and rear, an unusually large amount of window space has been provided. The single windows throughout the buildings are uniformly 4 ft. wide and 7 ft. high. All the windows are divided at the middle and have two galvanized-iron framed sashes set in galvanized-iron window frames. The glazing in all of the windows, except in three or four in the front on the fourth floor, is wire glass, which was made and furnished by the Mississippi Wire Glass Co. The windows on the first floor are placed singly or in pairs. On the other three floors they are for the most part placed in sets of three. On the side of the building exposed to the alley and on the two ends, these sets of windows have only a 4-ft. brick pier between the ends of the adjacent sets. In this manner, at the window levels on these floors, the only part of the sides of the building that is not framed or glazed, is that occupied by the 4-ft. brick piers between the sets of windows and those piers at the corners of the walls. The spans of the window openings on these floors vary from 10 ft. to 12 ft. 1 in., lintels of structural steel shapes being built into the walls to carry the load over each span.

The door openings through all of the outside walls and through the fire wall in the building are fitted with heavy fire doors. The doors on the outside walls are the jack-knife type. The remainder are automatic fire doors. The building is equipped throughout with an automatic sprinkler system for fire protection. This system is supplied with water from the 50,000-gal. tank on the roof, or by an electrically-driven underwriters' pump in the basement. A covered tank, with a capacity of 120,000 gal., is also built under the shipping space and driveway at the rear of the 96x118-ft. section of the building.

The fire hazard to which the building was exposed on the rear and along the side facing the alley was unusually great. A four-story frame lodging-house, divided into numerous small rooms was nearly completed on the opposite side of the alley, the two structures being 35 ft. apart. Along the side of this flimsy structure were piled 40,000 cross-arm timbers for poles for telephone and electric wires. This frame building and the cross-arms were completely consumed by the fire, almost without damage to the building of the Western Electric Co. The principal building at the rear of the latter building was a large three-story residence that was formerly one of the most pretentious residences in San Francisco. The remainder of the block on the rear of the Western Electric building was occupied by one and two-story frame buildings. This large residence and the smaller frame buildings were entirely burned out by the fire. The buildings in the immediate vicinity on the other two sides of the Western Electric Co. building did not offer any particularly great fire exposure to the latter. The fire dangers to which the building was subjected by the general conflagration were perhaps as great, however, as those brought about by the buildings in its immediate vicinity.

Houses on Van Ness Ave., San Francisco, Where the Street Sank Five Feet.

It is believed that the saving of the building resulted to considerable extent from the manner in which employees of the company fought the fire, although the construction and equipment of the building were the primary causes. The electric power to operate the fire pump was cut off from the start. The water in the tanks was thus necessarily held in reserve and was afterward of great value in fighting the fire by hand with buckets. The heat in the building was at no time great enough to open any of the automatic sprinklers. The plate glass windows at the front of the fourth floor were covered with corrugated sheet iron which prevented the flames from reaching the interior of the building through these openings. The windows glazed with wire glass needed no further protection. The contents of the building are entirely uninjured, and the local managers of the Western Electric Co. state that for some time to come they have all the materials which will be necessary to supply their trade.

This journal is indebted to Mr. W. R. Patterson, plant engineer of the Western Electric Co., for the preceding information.

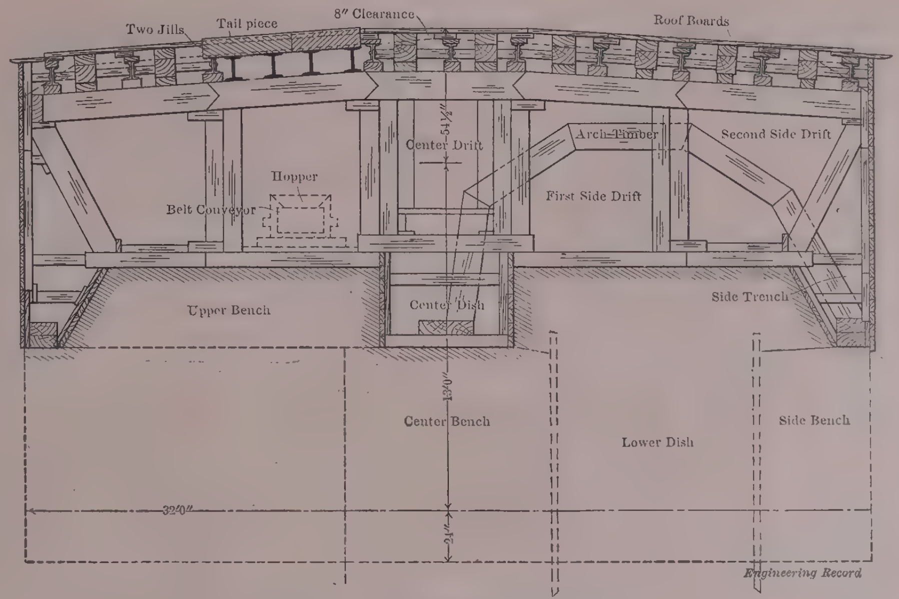
Early Asphalt Pavements in London.

Early asphalt pavements in Oxford St., London, are described in a recent issue of "The Engineer," of that city. These were laid for testing purposes late in 1838. The pavements in the order in which they were placed on the street were as follows: First were 40 ft. of Robinson's Parisian bitumen blocks 12 in. square and 5 in. deep, containing pieces of granite. Forty-four feet of granite block paving came next; the blocks were 9 in. deep and laid in Claridge's Leyssel asphalt. Twenty feet of granite block 4½ in. deep followed, and then came 60 ft. of 12x6x4-in. blocks of Bastenne bitumen. This was succeeded by 135 ft. of granite blocks with grout joints, where a concrete foundation was used and gravel joints where none was employed; all blocks were 9 in. deep. Next came 50 ft. of blocks 6½ in. deep made of Scotch asphaltum and jointed with Roman cement. Wood blocks treated in various ways and laid both with and without plank foundations were put down under the Stead patents for a length of 60 ft. Finally a pavement of Val de Travers asphalt was laid, part of it as blocks 5 in. deep and part as sheet asphalt containing granite chippings. In most of the block pavements a part of the length had the courses at right angles to the curb and a part had diagonal courses. Robinson's Parisian pavement failed in a month. In two months the Scotch asphalt blocks were in bad order. In four months the Val de Travers sheet pavement was ruined, although the blocks were standing well. In eight months the granite, wood and Bastenne bitumen blocks were alone in good condition, but it was held that the service given by the wood blocks was most satisfactory. They accordingly came into extensive use, but the failure to lay them on concreate foundations subsequently led to unsatisfactory results and an unwarranted bad reputation.

Leakage from Reservoirs, causing damage to property in the vicinity, was the subject of a suit before the New Jersey Supreme Court recently, 633, Atl. Rep. 6. The court ruled that when water confined in a reservoir escapes through its negligent construction or maintenance, adjoining landowners whose lands are thereby injurd, have a right of action to recover damages resulting from such injury.

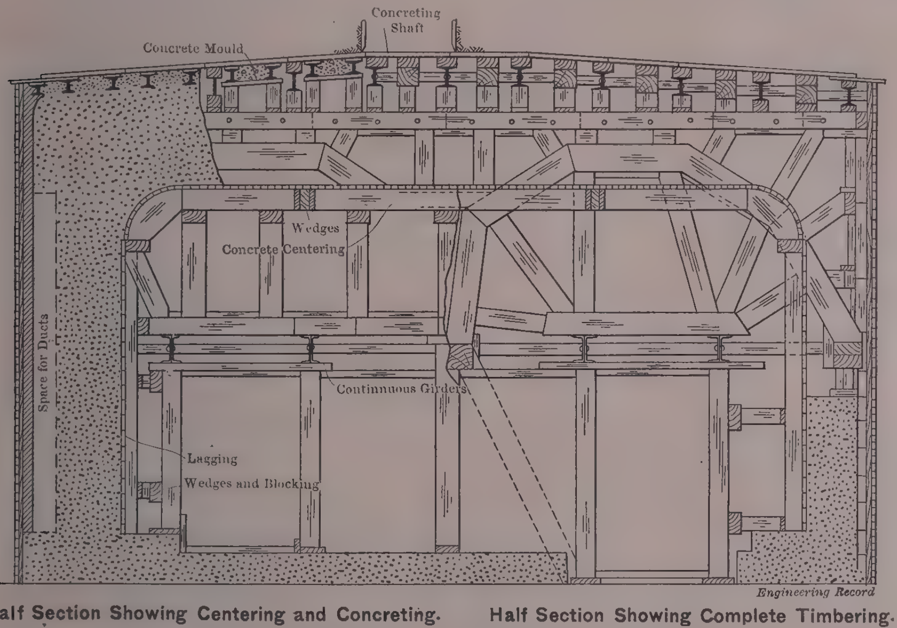
Recent Tunnel Construction of the Rapid Transit Railroad in Brooklyn.

Section 3 of Contract 2 for the New York Rapid Transit R. R. in Brooklyn connects at Joralemon Street with the two single-track tunnels under the East River, and continues in the opposite direction through Fulton St. and Flatbush Ave. to Atlantic Ave. Most of it has been constructed in open trench, as illustrated in this journal on Oct. 22 and 29, 1904 and Dec. 23 and 30, 1905. In the section, about 650 ft. long, from Court to Clinton Sts. where subgrade was from 33 to 52 ft. below the surface of the street, the double-track structure has been built in tunnels and its execution has now been very satisfactorily completed under difficult conditions. In this tunnel section there is about 325 ft. of double track rectangular reinforced concrete structure 27 ft. wide and 13 ft. 10 in. high in the clear, and 325 ft. of single-track brick-lined tunnels 15½ ft. in diameter inside, which connect the concrete portion with the single-track cast-iron tubes extending under the river. The single-track circular tunnels diverge till they are parallel and 26 ft. apart on centers, and have a lining of four courses of selected red brick laid in Portland cement mortar. Their horizontal alignment is a tangent except where they converge; the maximum grade is 3.1 per cent. At the junction with the concrete section the latter is widened to a maximum of 28 ft., inside width, in two spans. The roof here consists of a flat slab of reinforced concrete 2 ft. 8 in. thick in the center and 2 ft. 4 in. thick at the ends and has a core wall 16 in. thick for 125 ft. after which for 200 ft. there is a clear span of 27 ft. width, with 3 ft. 10 in. thickness of roof, which is believed to be the longest clear span of flat reinforced concrete structure ever built in tunnel. The street is at this point about 25 ft. wide between the curbs and 52 ft. wide between the building lines, and the center line of the tunnel corresponds approximately with that of the street except in front of the Temple Bar Building, where it is deflected somewhat so that the side wall of the tunnel is about 11 ft. from the house line.



Drifting for Reinforced Concrete Tunnel.

Both sides of the street above the tunnel were entirely covered by residences, stores and office buildings three stories or more in height, including the fourteen-story Temple Bar building, many of them being quite old with brick or rubble walls and footings not adapted to sustain any settlement or excessive strain. The soil is a coarse, dry sand with small stones, few of which, however, are more than 8 in. in diameter. The soil has little adhesion and showed, during the work, a tendency to run wherever excavated, especially when the removal of the larger stones left cavities into which quantities of fine material quickly flowed. Water and gas mains, conduits, and sewers are located in the street above the tunnel, and in some instances barely clear its roof. Their presence added considerably to the difficulties of tunneling, particularly where the drip from the sewers caused some undermining. At Clinton St. the tunnel crossed underneath a 3-ft. brick sewer without injuring it and no serious damage was done to the gas or water mains.



Half Section Showing Centering and Concreting. Half Section Showing Complete Timbering.

It was found impossible to excavate the headings without causing a slight settlement of the street surface which was attributed chiefly to the conditions caused by the presence of the pipes and sewers, and was at no time dangerous or important. The most noticeable settlement occurred after the first tube was completed and while the excavation was in progress for the second tube. Nearly all of the stoops of the adjacent houses were more or less affected by the street settlement, but no serious damage was done to any adjacent building. No ground was lost in the excavation below the tunnel roof and the street settlement was therefore confined entirely to that part of the work, no subsidence whatever occurring in the foundations of buildings below the tunnel roof, although in some cases the tunnel wall is within 3 ft. of the building line.

Owing to the character of the buildings, the traffic in the streets, the nature of the soil, the width of the excavation and its small depth below the surface, it was recognized that the work of tunneling would be an exceedingly difficult operation and require very careful treatment to accomplish it without danger of serious damage to the adjacent buildings. Careful study was therefore given to the problem by the contractors and engineers before it was decided what methods should be employed. It was obvious that the shield method was out of the question on account of the frequent changes of cross-section of the tunnel which could not be provided for either by a Greathead or Carson type of shield, furthermore shields are not well adapted to this ground on account of the tendency of the loose gravel to run in the large face, as has been demonstrated by the result of shield work under similar conditions. It was also believed to be impracticable to use a shield with compressed air as it would be impossible to produce a seal for it in such loose ground.

The only other well-known method for this class of work was the crown bar system, which was considered inadmissible for several reasons; first, because it requires hand drifting and hand poling, which, although suitable in very deep work or where the preservation of the surface is not imperative, would involve excessive settlement in this kind of ground and would endanger the street and building; second, because it is necessary to leave a large amount of heavy timber in the ground which will eventually decay and form cavities promoting future settlement to undermining; third, because of the voids that necessarily occur and cannot be properly filled behind the crown bars as the brickwork is completed except by grouting at an enormous and prohibitive expense; fourth, because, except when this system is supplemented by arched or segmental timbering permanently left in place, the progress of the tunnel construction is probably slower than that by any other system.

In view of these considerations it was decided to execute the work by a modification of a method previously used successfully, combined with features developed in the trench work of the adjacent sections of the subway, all of which have been described in previous articles in The Engineering Record. In this system the excavation is made with a center top heading, and its transverse extension under a roof composed of special steel poling boards. These are provided with tail pieces engaging the permanent roof boards and virtually constitute a sectional roof shield made of small units always under perfect control, operated by simple appliances and moderate force and so elastic that they are quickly adapted to any change of conditions or cross-section.

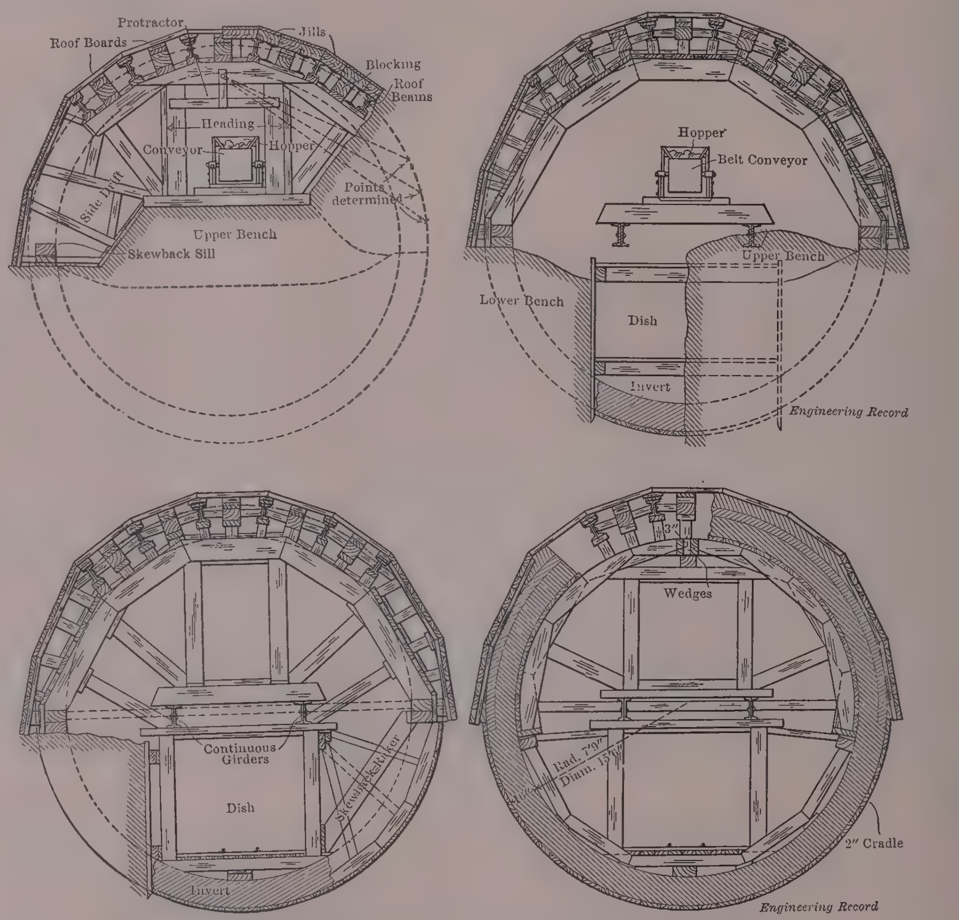
The poling boards and the roof which follows them are supported by heavy transverse bents, corresponding to ordinary timbering and reaching only to the bottom of the heading. After these are in position their vertical and inclined posts are replaced by arch timbers, which carry the roof without obstructing the excavation and thus afford clearance for completing the excavation, transporting the muck and building materials and finishing the work.

The upper part of the timbering is carried on continuous longitudinal steel girders, which enable the lower vertical posts to be arranged in convenient positions and to be shifted without interfering with the upper portion. Owing to the sectional advance of the headings there is very little opportunity for displacement of material. No voids are left outside the tunnel lining and no permanent timber remains in the ground. In the light of the experience gained and from a review of the completed work, the contractors feel that the method adopted has proved the safest, most expeditious, and most economical that could have been used under the circumstances.

The work in this tunnel differs from that in any former tunnel in the arrangement and combination of the successive operations, in some of their details, and especially in three features new to this work, namely, the method of keying the arch ribs for the concrete centers; the method of building the concrete work in alternate complete transverse sections in spaces where the timbering had been arranged to clear them and avoid any disturbance of regular bents; and in the use of belt conveyors to handle all the muck directly from the heading to the material tracks at subgrade in the finished excavation.

The double-track tunnel with the rectangular reinforced concrete cross-section was first built, and was a continuation of a structure of similar character previously built in open trench, as described in The Engineering Record of Dec. 23, 1905. It was started from the open trench at a point where the subgrade is about 33 ft. below the surface of the street and the roof of the tunnel is 14 ft. in the clear below the same level. Operations were commenced by setting up ten sectional shield sections 3 ft. wide and driving them in top drifts 8 ft. high and 5 ft. wide, timbered with bents 4 ft. apart on centers. Each bent consisted of a 12x12-in. transverse sill 6½ ft. long with the ends projecting into the sides of the heading, two 8x10-in. vertical posts and one 12x12-in. cap 6 ft. long with the beveled ends engaging those of the next pair. Each cap supported the two steel poling boards or shields sections 36 in. wide, 18 in. high and 15 ft. long over all. A convenient short name for these poling boards was required, and as they were supplemented by hydraulic jacks they were called "jills." The jack and jill together made one element of the sectional roof shield and could be operated by three men who, by the use of hydraulic power accomplished more and better work than could have been done otherwise and progress was more rapid and the work more safe.

This work was done with extremely small loss of material. Each jill consisted, as shown in the detail, of a pair of 10-in. I-beams 10 ft. long, connected by a transverse diaphragm and by heavy steel transverse bars bolted to their top flanges to support three 6x12-in. longitudinal yellow pine timbers projecting 18 in. beyond the front of the I-beams, where they were beveled to a cutting edge and covered with a steel plate ½ in. thick. This plate continued over the upper surface of the timber and projected about 3 ft. beyond its rear to form a tail piece, sliding over the roof of the heading and keeping all spaces closed against the entrance of sand or gravel from above. Each jill weighed about 200 lb., and was built by the contractors. The diaphragm between the I-beam webs was heavily reinforced to provide reaction for the 30 or 20-ton Watson-Stillman hydraulic pushing jack, which was set horizontally between the I-beams and engaged at the rear end a heavy longitudinal timber in the roof of the tunnel. The jacks were operated under a pressure of 3,000 lb. per square inch in the cylinder, by hand pumps connected to them by copper pipes.

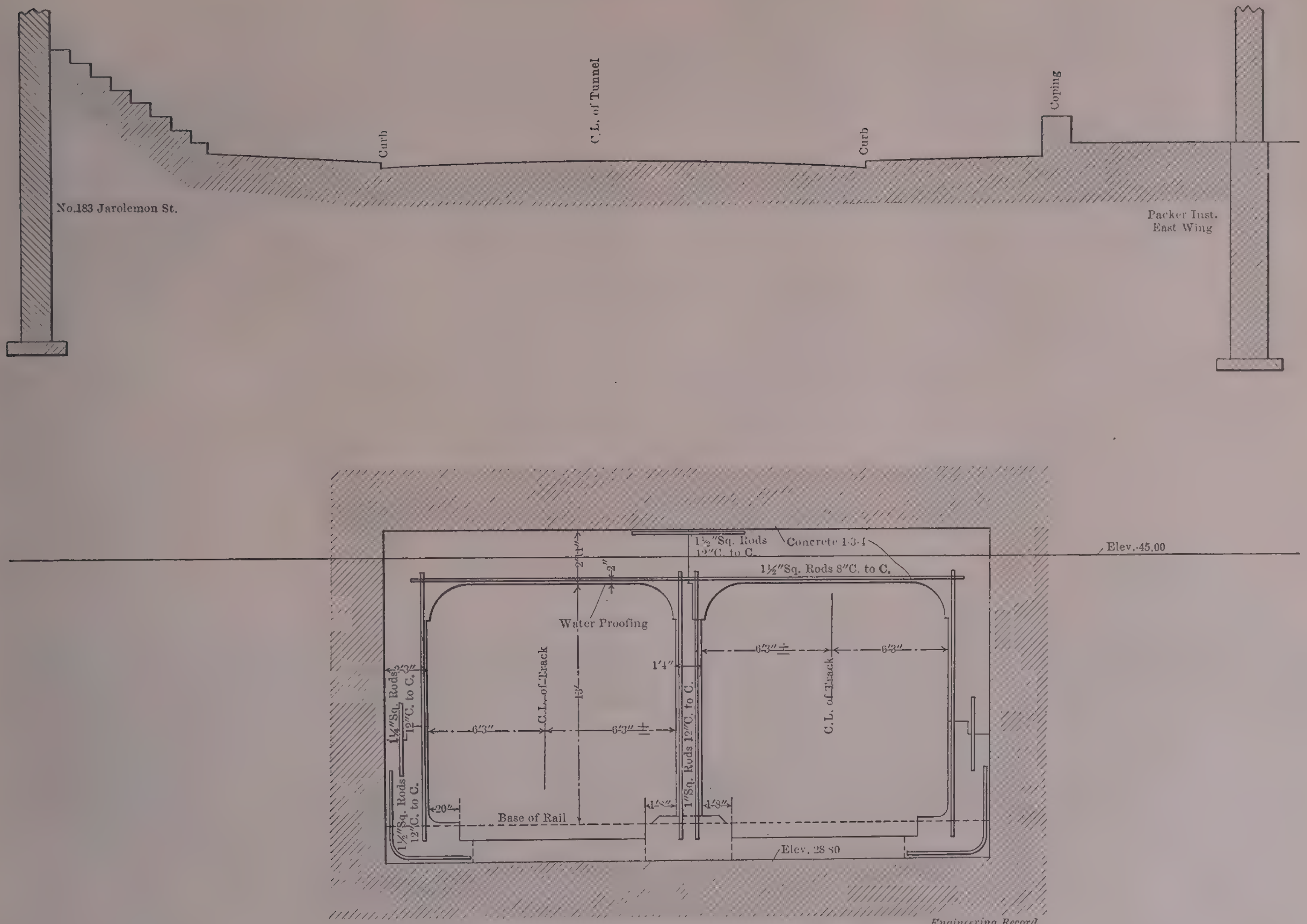


Successive Operations in Driving Circular Tunnel.

As fast as the jills advanced the spaces they vacated on the caps of the timber bents were occupied by longitudinal beams about 3 ft. apart on centers, which were wedged up to support the transverse roof boards 3 ft. long and 2 in. thick. Each longitudinal beam was made with one 18-lb. 8-in. I-beam, 6 ft. 4 in. long bolted to the next one back to back, with joints alternating, so that each beam spliced the other and a continuous girder was formed. The top flanges of these girders were 8 in. clear of the roof boards and supported them on blocking built up at each joint of the former. The lower flanges were wedged and blocked against the timber. Between these steel beams were ordinary wooden longitudinal beams supporting the roof boards at their middle points and serving as reaction beams for the jacks.

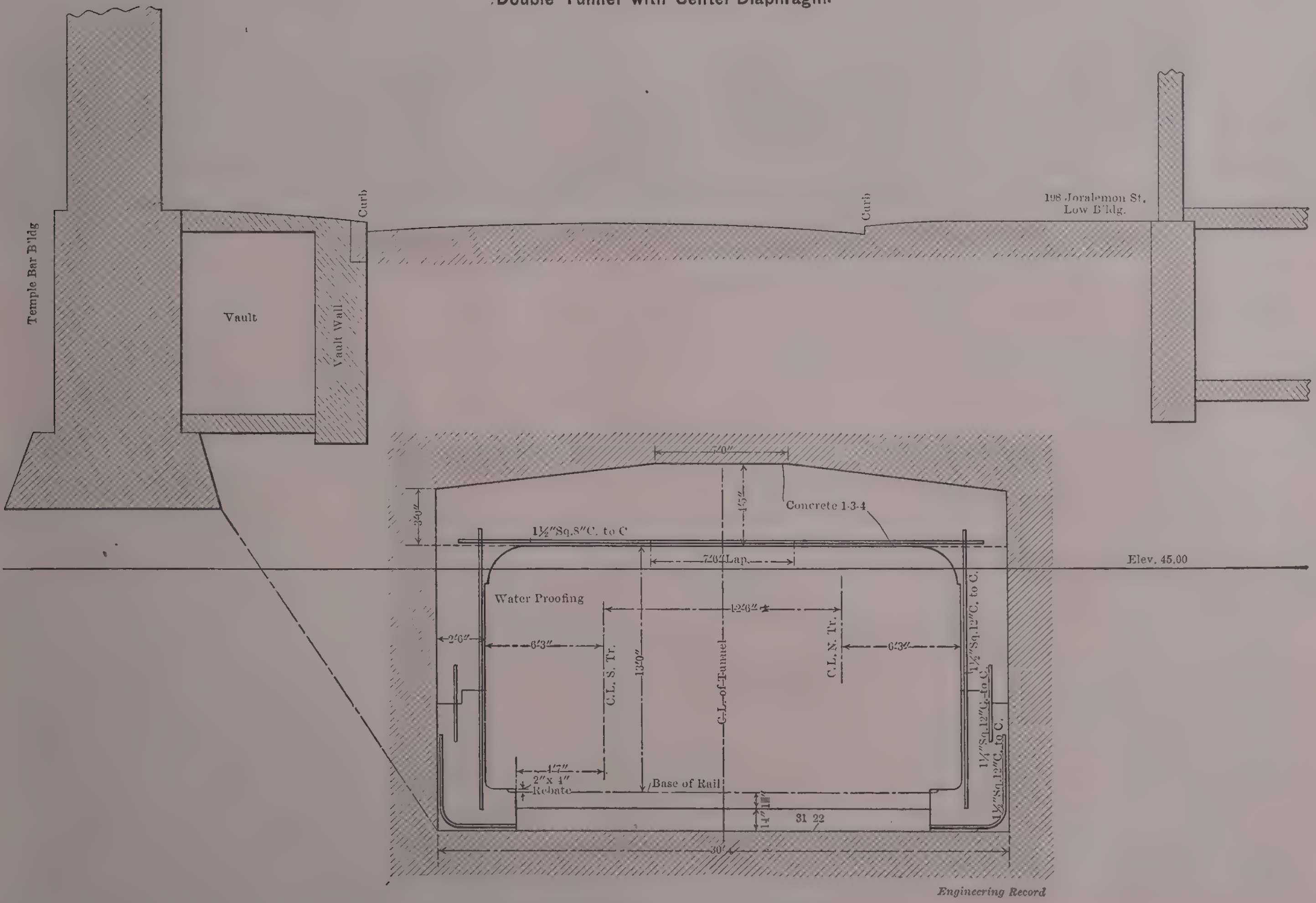
For the rectangular cross-section, the full width of 32 ft. was excavated with three top headings, the center one of four jills being driven first and kept from 15 to 25 ft. in advance of the two adjacent ones of three jills each. The side drifts were excavated and timbered in the same manner as the center drift, care being taken in all cases to sheet the sides as fast as the excavation was made with 6x2-in. horizontal boards in 5-ft. lengths. These boards were put in position from the top down, and the nature of the soil was such that they could be worked into place before any material ran into the drift and thus sufficed to prevent all loss of soil. For the center drift these boards served as temporary bulkheads. In the side drifts their outer walls formed the permanent sheeting which, with the roof boards, was the only wood left in the ground. The timbering for the drifts was special in that the transverse cap pieces about 6 ft. long were made with notched and pointed ends, fitting tightly and forming a bond at each joint, so as to give considerable continuity to the cap and make it act as a unit across the full width of the excavation, although it was inserted in very short pieces. The cross-section through the heading shows the first or upper story of timbering, but does not show all the jills. One pair of these is indicated and during construction they were so arranged as to cover completely the upper surface of the cap from side to side of the excavation, alternating as previously described with the longitudinal beams carrying the roof.

The muck was shoveled from the headings into hoppers that delivered it to the series of 24-in. belt conveyors by which it was continuously transported to the forward end of the finished excavation and dumped there into 1-yd. steel buckets on 18-in. gauge flat cars which were drawn by mules up grade to boom derricks which hoisted them to the surface. A conveyor system was installed in the drifts on each side of the center, consisting of one 24-in. Gandy belt 40 ft. long and two 24-in. Gandy belts 20 ft. long, thus providing a combined length of 80 ft. The conveyors were of the ordinary type, operated by General Electric motors. The framework and details were made very light and rigid so as to be conveniently handled in the tunnel and were spe-



Engineering Record

Double Tunnel with Center Diaphragm.



Engineering Record

Double Track Tunnel with Reinforced Concrete Lining.

cially designed for this purpose by Mr. Ralph Cranford. The equipment weighed only about one-third as much as those ordinarily used where stability and durability are of more importance than the requisites demanded for this special service. These belts were estimated to save the labor of a number of men and considerably expedited the work.

After the extension of the heading to the full width of the excavation, a dish or open trench about 5 ft. wide was sheeted down to a depth of 3 ft. on the center line of the tunnel and a narrow trench was excavated the same depth on each side, as indicated in the cross-section. Longitudinal sleepers were laid in the bottoms of the trenches and served as skewbacks for segmental bents, each composed of five arch timbers spaced 4 and 6 ft. apart, alternately and set intermediate between the bents of the first set of timbering. The caps were then wedged up from these arches, and the vertical and inclined timbers and transverse sills were removed, enabling the excavation to be carried down in two upper benches to below the springing line of the arches across the full width of the tunnel.

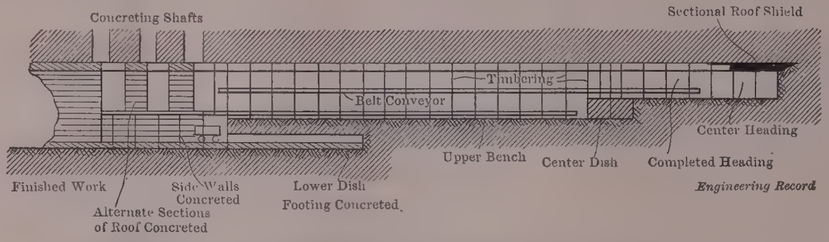
Afterwards another trench or lower dish, about 8 ft. wide and 8 ft. deep, was sheeted down on the center line of each arch to subgrade as indicated by dotted lines on the right of the diagram and in it were seated vertical bents in the planes of the arches. These bents carried longitudinal girders made up like those in the roof of the tunnel with pairs of channels bolted back to back and breaking joints to form continuous members. On these girders transverse beams were seated and inclined posts were set on them to support the arch timbers and permit the removal of their skewback sills. When this was accomplished the excavation was continued underneath them in two side benches and in a center bench between the lower dishes, completing the excavation.

After the completion of the excavation, the footings and side walls were built in forms in the usual manner, and centers were set up in the alternate spaces, where the arch bents, being 6 ft. apart, cleared sections of the tunnel 5 ft. long. This enabled a complete short section of the tunnel to be built in every second panel. After the concrete had set the centers were removed and the roof blocked up from the finished concrete to release the pairs of arch bents 4 ft. apart. These were removed and in the spaces they had occupied the arch centers were again set up and the roof and side walls were built connecting the concrete already placed on both sides and finishing the tunnel construction, except for the floor concrete which was put in between the footings at any convenient time.

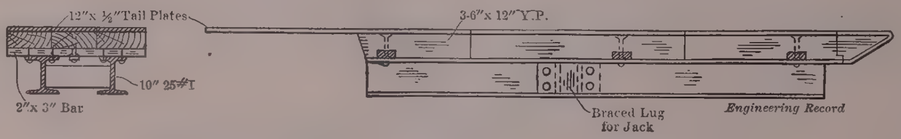
In order to deliver the concrete to the molds, small shafts were sunk from the surface so that each could serve two 5-ft. lengths of the tunnel, or when the depth of the tunnel below the surface was too great, a special heading was driven over the tunnel roof and the concrete was delivered through it. When the roof concreting was commenced, the longitudinal timbers between the steel roof beams were replaced by steel beams like those already set, made of short lengths of I-beams bolted together back to back at the overlapping ends so as to provide continuous girders. The narrow spaces between these beams were filled with Giant Portland cement concrete, rammed in longitudinally and supported on horizontal boards temporarily attached to the lower flanges of the beams. Only one or two of these boards would be set at once, thus leaving but a short space to be reached by the workmen, who rammed the concrete in place easily. After it was set the boards were removed and the molds were easily filled with concrete, rammed tight against the roof beams and roof concrete.

In this manner all voids were obviated and the steel beams originally used to carry the roof boards were permanently retained as reinforcement. These were made with 8-in. I-beams 6½ ft. long with the ends of their flanges cut off on opposite sides at opposite ends so that the webs of successive lengths overlapped and were bolted together. The arch centers or molds were made of longitudinal square-edge planed boards nailed to transverse ribs supported at intervals of about 30 in. by short vertical posts, wedged up from transverse beams across the top flanges of the continuous longitudinal girders previously mentioned.

The tunnel is parallel to the front wall of the Temple Bar building, which is about 140 ft. long and very high and heavy. It is supported on independent piers with loads of approximately 400 tons each on footings carried down about 17 ft. below the surface of the street. These footings are all 11 ft. horizontally from the side wall of the tunnel and 16 ft. above subgrade. A line drawn from the bottom of the footings to the bottom of the tunnel wall is thus considerably above the natural slope of the sand, and there was considerable apprehension that the tunnel excavation might destroy the equilibrium, so that the earth under heavy pressure would flow into the tunnel and undermine the building. Besides this footing a 12-ft. retaining wall for the sidewalk vault was located almost in the plane of the side wall of the tunnel with its footing in some places only 2 in. above the tunnel roof. This masonry wall was seated on the loose sand and the excavation under it was made so carefully that no settlement or cracking whatever was observed.



Longitudinal Section Showing Successive Operations in Concrete Tunnel.



Jill, or Special Poling Board forming Unit of Sectional Roof Shield.

At this point there was a large proportion of gravel and some large stones in the sand, and in order to prevent any flow of material, cement mortar was kept in readiness and a pailfull of it was spread on the back of each side board before it was put in position for sheeting the wall of the tunnel. This concrete was thus forced into the earth and filled all the cavities, effectually preventing any flow or loss of material and forming, when hardened, an excellent bond with the soil which also very much diminished the tendency of ground water to follow down the face of the wall, as it would have easily done had the latter been made with a smooth finish.

On the opposite side of the tunnel the side wall was within a few feet of the face of an old four-story brick building 60-ft. long with footings 22 ft. above the subgrade of the tunnel. Here the danger of undermining was evidently still greater, but the same methods of operation prevented it entirely and the work was done without any indications of settlement or injury to the building.

The construction of the circular brick-lined twin tunnels corresponded in general to that of the concrete tunnel, except for the modifications required by the differences in the cross-section. Operations were commenced, as indicated in the diagram of the first stage by driving a center top heading, like that for the concrete tunnel, and using in it the same jacks and jills there described. The caps in this timbering had their upper sides beveled at the ends and projected beyond the vertical posts so as to engage the joints of the side caps at each end, as indicated. After this five-jill heading was driven, it was widened carefully on each side and the remainder of the excavation was worked down simultaneously on each side, as indicated in the left side of the diagram.

The trench was extended down to the level of the horizontal diameter of the tunnel where it received sill pieces, which later served as skewbacks for the arch timber. The side excavation was executed with great care and was sheeted with horizontal longitudinal boards, worked in from the top as already described, but in this case it was not necessary to back up the boards with mortar as was done near the Temple Bar building. The position of the sheeting boards was very easily determined by a simple device indicated in the sketch, which enabled the miners to place them with sufficient accuracy. A T-shaped wooden protractor frame was suspended from a point in the axis of the tunnel, accurately determined by line and level observations. This frame carried one mark on the vertical leg and three at each end of the horizontal piece. The miners stretched a line from the center point to the horizontal points successively, measured off the required distances and thus located points in the outside of the arch ring where the sheeting boards were tangent to it, as indicated by the dotted radial lines. In this way the excavation and sheeting were nearly kept accurate until checked by the engineers.

After the side trenches were carried down to the springing line on both sides, arch timbers were seated on the skewback sills 5 ft. apart, and the longitudinal roof timbers and the I-beams were wedged up on them, as described, for the rectangular section. The original timbers, being thus released, were removed, and the conveyor belts were supported on transverse ribs seated on longitudinal girders laid in shallow trenches. These girders, like those previously described, were made of short channels bolted together back to back with staggered joints so as to form continuous members. After they were in position, they were supported on blocking while the core of earth was excavated under them to a depth of about 3 ft. below the center line of the tunnel. A ditch or "dish," as it is called, some 8 ft. wide and from 15 to 30 ft. long, was then sheeted down to subgrade on the center line of the tunnel and in the bottom of it cradle boards were placed and the permanent brickwork of the invert was laid, with the sides racked off to receive the upper sections. Sills and sleepers were laid on this invert to receive vertical posts carrying the longitudinal girders and from which the arch timbers were blocked, as shown. The horizontal plank floor was then laid on the transverse sills, and on it was placed an 18-in. gauge track for muck and material cars. Narrow transverse pockets 5 ft. apart were then excavated on each side of the dish, and in them inclined timbers (skewback rakers), were placed bracing the skewback sills. The excavation of the lower benches was then completed between the pockets, care being taken to trim the surface to correspond with the outer tunnel lining. The earth was covered with horizontal sheeting boards fitted to segmental transverse ribs and braced to the timber bents by radial struts, as indicated in the cross-section.

The brickwork was built up simultaneously on both sides of the invert to the springing line, above which it was continued to the crown on ordinary lagging and centers braced to the timbering by radial and transverse struts. The longitudinal roof-beams and timbers were removed as the brickwork advanced, and the spaces between the outer course of bricks and the roof-boards were filled solid with brick masonry. Great care was taken on all occasions to keep the roof sufficiently high and this resulted sometimes in the formation of small spaces above the four courses of brick required by the design. When this was the case one or even two additional courses of brick were built to fill in the space. The arch centers were of the usual type, consisting of three thicknesses of scarf boards bolted together to break joints, but were special in that they were made in halves separating at the crown. Each half had three tranverse ribs connected at the ends by longitudinal pieces. The two pieces at the upper ends were normally separated about 3 in. in the clear, and this space was filled with blocks and wedges which were adjusted to bring the outer surface of the lagging to the exact required position, forcing the lower ends to secure bearing on the skewbacks and holding the center in position until the arch was sprung, after which the center was easily withdrawn by removing the wedges. This device operated very satisfactorily and was considered a great advantage in the execution of the work.

Where the brick tubes are parallel, they are 9 ft. apart in the clear, but they converge until their walls are tangent at their junction with the concrete construction. One of them was completed before the other was commenced, and when the construction of the second one was commenced the excavation tangent to it and 17 ft. below the center line was thought to cause serious danger of undermining. The brick work of the first tube was, therefore strengthened by interior longitudinal timbers and bearing pieces, carefully wedged against vertical posts so as to stiffen the brickwork and distribute its weight over about 20 ft. of its length. The excavation of the second tube was, however, accomplished so carefully that no soil was lost and practically no settlement or distortion whatever was observed in the first tube, a result worthy of mention. The headings of both tubes met those of the tubes previously constructed from the opposite direction without any variation from the established line and grade.

The work was done under the plans and specifications of the New York Rapid Transit Railroad Commission, Mr. George S. Rice, chief engineer; Mr. Alfred Craven, deputy chief engineer; Mr. Frederick C. Noble, division engineer; Mr. Svere Dahm, general inspector of designs, and Mr. Lazarus White and Mr. J. M. Goodridge successively engineers in charge. The contractor is the Rapid Transit Subway Construction Co., Mr. George H. Pegram, chief engineer, and Mr. Percy Litchfield, division engineer of Section 3. The contractors for this section are Messrs. Cranford & McNamee, Mr. W. V. Cranford, Mr. John McNamee and Mr. F. L. Cranford, active partners. Mr. F. L. Cranford had charge of the work, Mr. J. C. Meem, being their chief engineer. Mr. W. I. Johnson was superintendent of the Joralemon St. section.

SLIGHTLY ALKALINE WATERS are commonly assumed to have no effect on iron, but experiments by Messrs. C. H. Cribb and F. W. F. Arnaud indicate that this opinion may be wrong. They suspended polished strips of steel or iron in very dilute solutions of sodium hydrate, calcium hydrate and sodium carbonate for 24 hours and then determined the weight of the oxide of iron in suspension and in solution. Most experiments were made at the temperature of the air and at 100° Cent. The results are given in a paper before the Society of Public Analysts. The maximum effect was obtained with solutions containing 1 to 1.5 c. cm. of N/10 hydrate solution per 100 c. cm. of water.

Relining the Allegheny Tunnel, Pennsylvania R. R.

Since 1898, westbound trains on the Pittsburg division on the main line of the Pennsylvania Railroad have passed through a double-tracked tunnel 3,600 ft. long at Gallitzin, Pa., about eleven miles west of Altoona. This tunnel, which was constructed in 1851-55, has a horseshoe cross section normally 24 ft. wide and 20 ft. high in the clear. Although supplied with two tracks it was considered too narrow and dangerous for double-track and freight service and no other train was allowed in it during the transit of a passenger train, although freight trains were sometimes permitted to enter simultaneously on both tracks. Except for a length of about 700 ft. which was unlined, the tunnel had cut stone masonry side walls battered up to the springing line and carried above it with the arch curve to a point about 45 degrees above the skewback, although in some places the stone masonry only extended as high as the springing line. Between the side walls the tunnel roof was a five-ring arch of common red bricks of 24 ft. clear span.

Arching Unlined Tunnel.

Repairing Roof Arch.

The tunnel was driven through irregular strata of shale, sandstone, slate, clay, limestone and other materials common in this region of coal formations. It was constructed entirely by hand labor with six headings driven from the portals and from four intermediate shafts and owing to the deterioration of time, it presented an irregular and dilapidated condition when repairs were made to it in 1905. Just previous to this a new single-track tunnel of the same length had been driven 80 ft. north from it to accommodate one of the two west-bound tracks, as described in The Engineering Record of last week. After the new tunnel was put in service the traffic from the old tunnel was diverted to it and the latter was repaired.

The continued action of the locomotive gases combined with the moisture of the tunnel, possibly augmented by solutions dripping through the roof, had greatly injured the brick lining, the soffit of which was very spongy and friable in most places so that it could be easily crushed or removed. Nearly everywhere the first course of bricks was practically destroyed or even entirely missing. In many cases the second course was in the same condition and in some places the injury had penetrated to the third course. The fourth and fifth courses were not injured. The condensation and moisture gathered on the lining had formed great patches of black fibrous substance on the walls but had not injured them.

It was decided to rectify the grade and roadbed, to line the unlined portion of the tunnel and to restore the soffit of the brick arch. The first work done was to line up the grade, which required the removal of muck and broken stone and in some places the excavation of rock. This occupied six weeks during which time about 4,000 cu. yd. of material were removed.

Eight timber platforms were meanwhile provided and were seated on wooden sills close to the bottoms of the side walls. These platforms were located at approximately equidistant points in the tunnel and on them men worked clearing away the imperfect portions of the roof arch for one, two or three courses as was necessary.

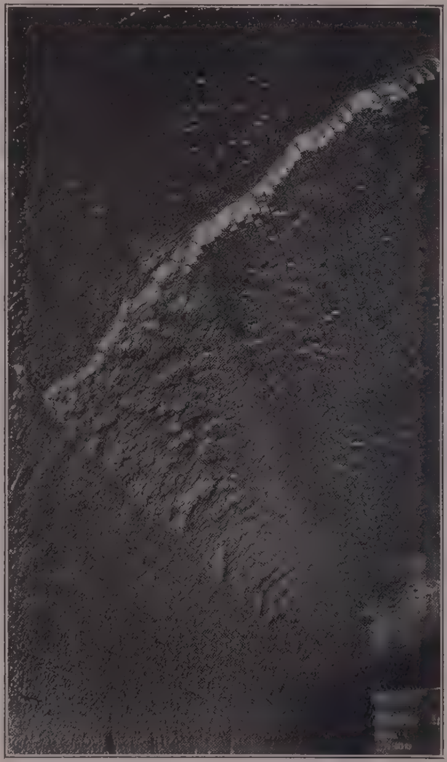
Following each of these platforms was a bricklayers' scaffold or center 20 ft. long, supported on a movable tower. The tower was built of two vertical longitudinal frames close to the walls, each having 10 x 12-in. sills and caps and five 10 x 12-in. vertical posts 5 ft. apart. The caps supported the extremities of arch centers made for a segmental soffit of 12 ft. radius. The centers were 5 ft. apart and each was made in the usual way with double staggered thicknesses of 3 x 12-in. scarf boards and had at the haunches a single 3 x 12-in. horizontal tie 17 ft. long. A 3 x 12-in. vertical piece at the center braced this tie to the crown and made a very rigid and simple framework.

The center was additionally stiffened by a 3 x 12- in. knee-brace from each end to the vertical post of the same bent, thus forming with the side frames a tower of considerable transverse strength which had clearance for trains through it. Horizontal 3 x 12-in. planks extended from the ends of the arch centers to the knee-braces. but were discontinued at the latter point so as to afford clearance for the upper parts of the trains in case it were necessary to run them through the tower. The arch centers were connected to the longitudinal caps by angle iron bolted to both members.

The tower moved on loose wooden rollers carried by longitudinal timber sleepers. After the men on the advanced platform had cleaned a 20-ft. section of the roof the tower was moved forward under it and was jacked up off the rollers until the arch centers were in the required position. Lagging boards 2½ in. thick were then put on the centers, commencing at the lower ends in the usual way, and the brickwork was built up one, two or three courses thick as required, like new construction, by a party of four bricklayers on each side of each tower. They worked on a platform at the level of the longitudinal caps which was, however, movably supported so that if at any time instructions should be received to prepare for the passage of trains it could readily be removed and afford clearance for a locomotive. The contract provided that the railroad company might commence traffic at any time after a 4-hr. notice but it did not eventually prove necessary to do so and the work was carried on without interference from trains.

In one 10-hr. shift the bricks were laid up to the crown, and then one man keyed the arch in one night shift. The next day the bricklayers advanced to the second tower and laid another 20-ft. section of the arch, and so on for the third and fourth days. On the fourth day the brickwork over the first tower having been fully completed for 48 hr., the tower was lowered, carried forward 20 ft. and raised in position so that on the fifth day the bricklayers resumed work on that tower. This sequence was then repeated, each arch being supported for 48 hr. after the brickwork was finished above it.

Duplicate operations were carried on at both ends of the tunnel, keeping all the eight towers in constant use with two sets of bricklayers. The towers first completing their sections of brickwork up to the starting point of the next tower were taken down and put to work assisting other towers to complete their allotments, and as these were finished they were moved to the unlined section of the tunnel and there operated simultaneously to build its new brick work. For this service the centers were extended by side pieces continued beyond their lower ends. These side pieces were attached to the vertical posts by means of bolts through horizontal slotted holes which enabled them to be moved back and forth and adjusted to the exact position of the arch soffit. The new roof was built in the ordinary manner and all spaces above it were packed tight with dry rubble or masonry. In many places it was necessary to drill and blast in order to trim the irregular rock surface to clear the arch and new sidewalls. This required a party of 20 men on day shifts and 20 men on night shifts.



Arch Damaged by Smoke.

The work was commenced on Sept. 1, 1905, finished Dec. 13, and the first train passed through the tunnel Dec. 20. There were used for this work 1,000,000 wire-cut fire clay paving bricks manufactured by the Reese-Hammond Fire Brick Co., Bolivar, Pa., and 1,000,000 vitrified shale bricks manufactured at Johnstown and at Windber, Pa. They were all laid in mortar, 6,000 bbls. of Whitehall Portland cement being used.

Work was done under the direction of the operating department of the Pennsylvania Railroad, Mr. A. J. Whitney, Jr., principal assistant engineer in charge, by Mr. P. F. Brendlinger, contractor.

Pneumatic Foundations and Tunnels can be carried out at a depth of 210 ft. below the water surface, according to Messrs. Leonard Hill and M. Greenwood. They experimented on the effect of air pressures up to 92 lb. by means of a large cylinder, in which they stayed under different pressures for various times.

Fireproofing the Steel Work in a Large Office Building.

Great pains have been taken to render the new office building of the New York Central & Hudson River R. R. absolutely fireproof by thorough protection with concrete of all the steelwork, including the columns, girders and trusses. Horizontal 1x⅛-in. steel bars 30 in. apart are clamped around the column flanges and project about 2 in. from them diagonally to receive vertical ½-in. rods that serve as a framework around which is wrapped galvanized wire cloth. The cloth is applied in strips stiffened by horizontal bars about 15 in. apart, and is backed up as fast as secured, by cinder concrete packed in between the cloth and the column. After the column is entirely jacketed in this manner the rough coat of plaster is applied on the outside of the wire cloth just covering it and thus making a protection that will undoubtedly endure fierce heat and water jets without being detached.

The lower flanges of deep I-beams and girders which project below the ceiling line will be similarly protected by concrete filling between the metal and wire cloth stretched over rods secured to the corners of the steel members, as described for the columns and as indicated in the accompanying detail sketches. The same system of skeleton furring and metalic lath is also designed for the end posts of the trusses. The intermediate diagonals and verticals, which are made of pairs of angles back to back are simply wrapped with wire cloth concreted on both sides. The top and bottom chords of the trusses are furred and concreted in a manner corresponding with that for the deep I-beams and girder flanges.

The 7-ft. twin girders at the Lexington Ave. floor in the 45th St. front of the building (see Eng. Record, March 17) will be protected by filling the 2-ft. space between their webs with a solid mass of concrete, and enclosing their outer surface with a thin layer of concrete and mortar on both sides of a wrapping of galvanized wire cloth. This wire cloth will be attached to the webs, as indicated in the cross-section, by means of 2x3/16-in. vertical bars about 30 in. apart, fastened to the webs with horizontal bolts and 2-in. thimbles. The adjacent box girders carrying the outer wall will be fireproofed in exactly the same manner and the concrete protecting their lower flanges will form a continuous surface nearly 6 ft. wide, with the edges flanged downwards to enclose the supporting 10-in. horizontal channels. These will form parallel ribs about 8 in. deep, which will be connected by light horizontal furring channels 12 in. apart bolted to them and covered with metallic lath and mortar so as to enclose an air chamber below the bottom flanges of the girders where they are most exposed.

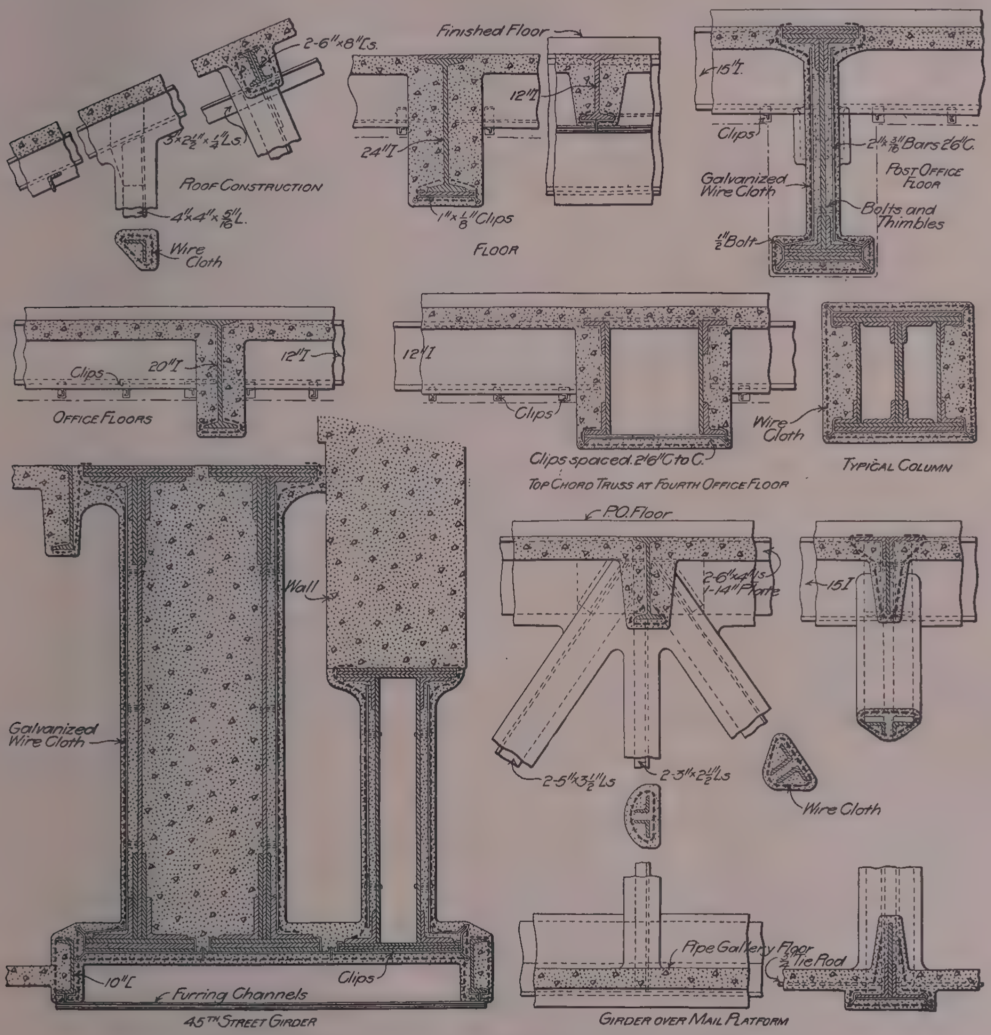
The driveway at Depew Pl. is carried over the tracks by steel beams and girders and a concrete floor. The latter is finished by a very heavy fillet of concrete, reinforced near its concave outer surface with a layer of galvanized wire cloth, and is protected at the angles and at the upper part where it serves as a sort of curb by angles and channels with the flanges turned inwards and securely anchored to the concrete, as indicated in the sectional detail.

Very handsome grills of steel and cast iron have been designed for the windows and doors in the first story. All of the window frames and sashes are of cast iron of special design, as are ornamental plates under the window sills, which are backed up with hollow brick and concrete. These plates are anchored to the floorbeams and are connected to the ornamental perforated plates which serve as screens enclosing the direct-indirect radiators under the windows and are hinged top and bottom. The window frames and sashes are made of drawn bronze bolted to channels and of cast iron bars and mullions.

This building is part of the work due to the change in motive power from steam to electricity, in charge of Mr. W. J. Wilgus, vice-president of the company. Reed & Stem and Warren & Wetmore are the associated architects. Mr. Charles A. Reed is the executive architect; Mr. H. G. Balcom is in charge of the steel work and structural designs, and Messrs. Leem & Schultze, of the architectural design. The John Price Co. is the general contractor. The contract for the structural steel work has been awarded to the McClintic-Marshall Co.

Concrete Seats at Revere Beach.

Concrete seats arranged like "bleachers" have been planned by the Metropolitan Park Commission of Boston for the slope in front of the terraces and bathhouse at Revere Beach. It is proposed to cover an area about 500 ft. long and 25 ft. wide with concrete, in the form of steps 2½ ft. wide and 6 in. high, with a smooth granolithic surface. These can be cleaned each morning by sweeping or flushing with water, thus saving the expense of keeping the present stony surface free from paper, rubbish and fragments of food.



Fire-proofing Methods in Office Building of New York Central R. R.

Damages for Injury Due to Blasting were recently awarded against a railway contractor by the Kentucky Court of Appeals, 91 S. W. Rep. 254, which ruled that anyone engaged in railway grading who made blasts in such a way as to throw rock and earth on adjoining land, to the injury of the owner, was liable for damages, irrespective of the question of negligence.

Test of a Turbine-Driven Sirocco Blower.

A test of a pair of Sirocco pressure blowers, direct driven by a 300-h.-p. De Laval steam turbine was conducted at the works of the De Laval Steam Turbine Co. by Messrs. W. H. Titus and P. S. Rattle while undergraduates at Cornell for a thesis investigation, for the purpose of determining the efficiency of the combination under different loadings as well as the characteristics of the blower. The tests were essentially efficiency tests, but interesting determinations and observations were made which have a bearing upon the performance of this combination. The blower set tested was an equipment which had been built for the Laclede Gas Company, of St. Louis, consisting of a 300-h.-p. turbine and two 20,000-cu. ft. blowers, all mounted upon a single-base plate, the turbine driving through the usual De Laval reduction gearing, to a blower on each of the twin reduction shafts. The reduction gearing is in proportion of 11 to 1, the turbine wheel revolving at about 10,500 r.p.m. to operate the blowers at about 900 r.p.m. The turbine is fitted with 15 expanding steam nozzles, ten of which are designed for condensing operation and the remainder for non-condensing. The turbine was operated with very dry saturated steam, but exhausted into a Worthington barometric jet condenser which rendered measurements of the steam consumption by condenser discharge impossible. The construction of the turbine wheel and shaft is that usual in the De Laval turbine, the flexible shaft being supported by three bearings, those on either side of the wheel being self-aligning, to permit the wheel to revolve on its true axis when operating at speed.

Each blower had a fan wheel of 48 in. pitch diameter and was rated to deliver 20,000 cu. ft. of air per minute against a pressure corresponding to 21 in. of water. The discs of the impellers or runners were of cast steel, coupled to the reduction shafts of the turbine by flexible couplings, and the blades were of aluminum, each 2 3-16 in. in radial width. Each fan was enclosed in a spirally formed casing of rectangular cross-section built up of ¼-in. boiler plate steel. The entire space within the runner served as the inlet opening, equal in section to that of the discharge orifice. The radial depth of the blades was one-sixteenth of the diameter of fan; the axial length of the blades was three-fifths of the diameter of the fan; the number of blades was 64.

The set was mounted on wooden blocking, the absence of vibration in operation of this combination obviating the necessity of clamping rigidly to floor plates, and connected to a boiler of the power plant adjoining the testing room at the works by a 5-in. steam line; a thermometer was inserted in this main for determinations of the quality of the steam. The exhaust connection to the barometric condenser was a 12-in. line. Steam gauges were also connected in the steam supply on both sides of the governing valve and to the vacuum side of the turbine wheel, in order to measure the vacuum. As a jet condenser was used, the steam consumption was determined by means of a nozzle test, made by connecting a turbine nozzle of similar size and shape to those used regularly in the operation of the turbine, into the wheel casing, by means of which the steam might be delivered to an independent condenser for actual measurement. This was accomplished by piping the discharge from this test nozzle into a barrel of water placed on a pair of scales, so that the flow through the nozzle for any given period of time could be determined by weight of the condensation added to the barrel.

The blowers were arranged to discharge into a large pressure box, 14 x 6 x 6 ft. in size inside, having a discharge nozzle 2 ft. 9 in. square in cross-section which opened to the outside air. A water gauge was connected into the pressure box, for the measurement of the static head, at a point where the reading would be least likely to be affected by the velocity of the passing air. A similar pressure gauge was also placed in the channel of the exhaust nozzle to measure the static pressure there. The velocity of the air in the box was measured by a Pitot tube, while the velocity of discharge from the orifice was measured by a Pitot tube of small opening which was adjustably mounted in front of the exhaust opening and so arranged that it could be moved longitudinally entirely across the nozzle. For the determination of the relative humidity of the air a psychrometer was mounted in the intake opening of one of the blowers where the thermometer bulbs came freely in contact with the maximum velocity of the air at intake.

The testing of the blower set involved two operations, one for the output of the combination and the other a brake test of the turbine with the blowers removed. For the latter, the two blowers were disconnected and removed from the bedplate, and two Prony brakes substituted upon the blower drive shafts. These brakes were of the water type, being arranged for flooding the blocks of wood composing the friction members. For convenience in calculation, the arm of each brake was made exactly 7 ft. from the center of the blower shaft to the point of suspension of the balance weights.

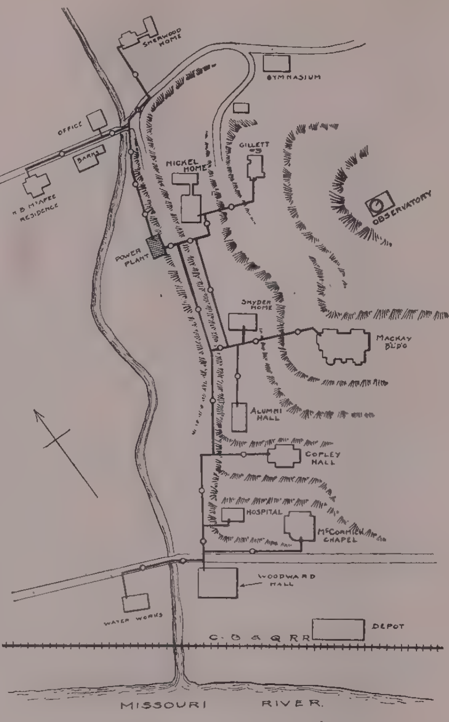
The procedure in testing began with running the set a number of times in order to secure good average operative conditions and adjusting the exhaust nozzle from the pressure box so that the static pressure in it was maintained at 21 in. of water column. Then, before each test run, the set was run under these conditions for one-half hour before readings were taken. The first test was a one-hour run, consisting of five minutes' readings of both water gauges and Pitot tubes, the psychrometer, number of revolutions per minute of the blowers, steam pressure above and below the turbine governor valve, vacuum from the condenser, and temperature of steam in the supply pipe. Readings of the steam consumption were also made by means of the test nozzle, to accomplish which the nozzle discharge was opened into the atmosphere so as to remove all condensation and warm up the nozzle, and subsequently the discharge was turned quickly into the barrel on the scales for measurement of the nozzle discharge by condensation; this operation was facilitated by a three-way cock in the nozzle discharge line to the barrel, so connected as to quickly discharge into the barrel or to the outside for exact timing. The steam consumption of the test nozzle was ascertained in advance of each of the five minute readings by a two-minute run into the barrel after which the increase in weight of the barrel of water was carefully determined, giving thus a measure of the steam consumption of each of the ten nozzles of the turbine at the pressure of steam in the turbine wheel casing. There were five readings taken on the small Pitot tube in front of the air discharge nozzle at every five-minute period, in different positions in front of the end of the nozzle. Two additional test runs were made in exactly the same manner as the first except that the duration of each was 20 minutes and the static pressure in the second run was somewhat below 21 in. of water and in the third run somewhat above that pressure. These runs were of short duration, but were justified by the fact that the set was operated for one-half hour prior to beginning the test and after that the load was an absolutely constant one so that long-extended tests were considered entirely unnecessary.

In the second series of tests, with the blowers removed and Prony brakes substituted upon the blower drive shafts, there were two runs made, in each of which the machine was started and the load on the brake arms so adjusted that the speed, number of nozzles open and pressure below the governor valve were practically identical with those in the first and second blower runs. After the machine had become thoroughly warmed up under this load readings were taken every five minutes for a period of 15 minutes, as follows: steam pressure above and below turbine governor valve; vacuum from condenser; temperature of the steam; steam consumption per nozzle; revolutions per minute at the brake wheel and the net loads on the brake arms. The second brake test run was made exactly as at first except that the running conditions were adjusted to correspond with those of the third blower test run. The psychrometer indications were noted in each of the above runs.

In the determinations of the steam consumption per air horse-power and the efficiency of the blower, the volume of air delivered by the blower was first calculated, allowance being made for the weight of the atmosphere due to the aqueous vapor contained. The velocity of discharge at the pressure maintained in the air box was found to approach very closely to 297 ft. per second, and from this the amount of air discharged was easily calculated to be 41,786 cu. ft. per minute. As the work expended in moving the air was equal as the work done by it in expanding, the air horse-power was calculated from the usual formula to be 130.65 h.-p.

The result of both blower and brake tests indicated the average weight of steam used per nozzle in 2 minutes was 14.38 lb. and thus 4,316.4 lb. for all ten nozzles per hour. From this the steam consumption per air horse-power was readily found to be 32.91 lb. The brake tests made on the turbine with the blowers removed indicated that when operating under conditions similar to those encountered when driving the blowers, the power delivered was 221.7 B.h.p.; as the air horse-power delivered at the blowers, 130.65 air h.-p., required 221.7 B.h.p. at the turbine reduction shafts, the efficiency of the combination was calculated at 58.99 per cent.

The objections to the nozzle method of measuring the steam consumption in the turbine were considered, but it was thought that this method would be as nearly accurate as any other which might have been attempted. It has been extensively used for nozzle turbines with excellent results and has advantages over the use of the surface condenser in that the almost inevitable leakage of condenser tubes is not present to cause discrepancies in the results secured. Although a thermometer was inserted in the steam pipe supplying the turbine, no corrections were made in the steam consumption records as the steam was found to be practically dry and saturated throughout; this was due to the fact that the steam was passed through a superheater which, however, as operated added no superheat to the steam delivered. Accordingly the steam economy was figured as the steam was actually measured and no reduction made to dry basis.



Park College Distribution System.

In conclusion it was noted that when the blowers were operated to their normal capacity the turbine was carrying only about 70 per cent. of its full-rated capacity, this proportion in design having been made to enable the turbine to meet sudden demands in the service for which it is to be used. This accounts to some degree for the relative high steam consumption per air horse-power per hour, although the figure obtained is by no means excessive. It was shown that if tests with overload had been run, a much lower steam consumption would have resulted.

The Aluminum Industry will not be materially affected by the expiration last month of the Hall basic patents, which have been the cause of so much litigation in the past. These all relate to the electrolysis of alumina dissolved in fluorides, and their expiration permits anybody to use the only electrolyte at present of commercial importance. The Pittsburg Reduction Co. retains its monopoly of aluminum production in this country, however, by virtue of the Bradley patent, covering the method of heating the electrolyte by the electric current.

Central Heating Plant for Park College, Parkville, Mo.

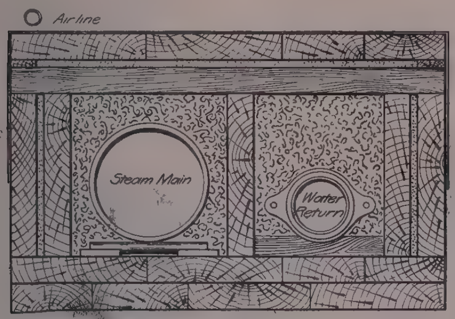
A central steam heating plant has recently been installed for the buildings of Park College, at Parkville, Mo., a suburb of Kansas City, 10 miles to the northwest on the Missouri River. The college has about 400 students, and has 16 separate buildings, two of which, however, the observatory and gymnasium, are not connected with the heating system. The buildings are distributed on the terraces of a high side hill, sloping back from a small stream tributary of the Missouri River, so that their elevations range from 15 ft. below to 150 ft. above the power house floor.

The Schott regulated vacuum system of heating was installed, in which condensation is returned to the power plant by gravity. Steam is supplied from a station nearly centrally located on the college campus, by a system of underground mains to the various buildings, in each of which there is a thermostat and an automatic control valve, automatic air vents on all radiators and a trap and check valve on the condensation outlet which controls the returns. Condensation is returned by gravity to the station from all but two buildings through pipes in the same conduit with the supply mains. The two buildings without a return to the station are situated too low to permit of gravity return, so the condensation from their systems is wasted, after passing through radiators in the water-works building, which is thus warmed by the hot condensation and without the use of steam from the supply main.

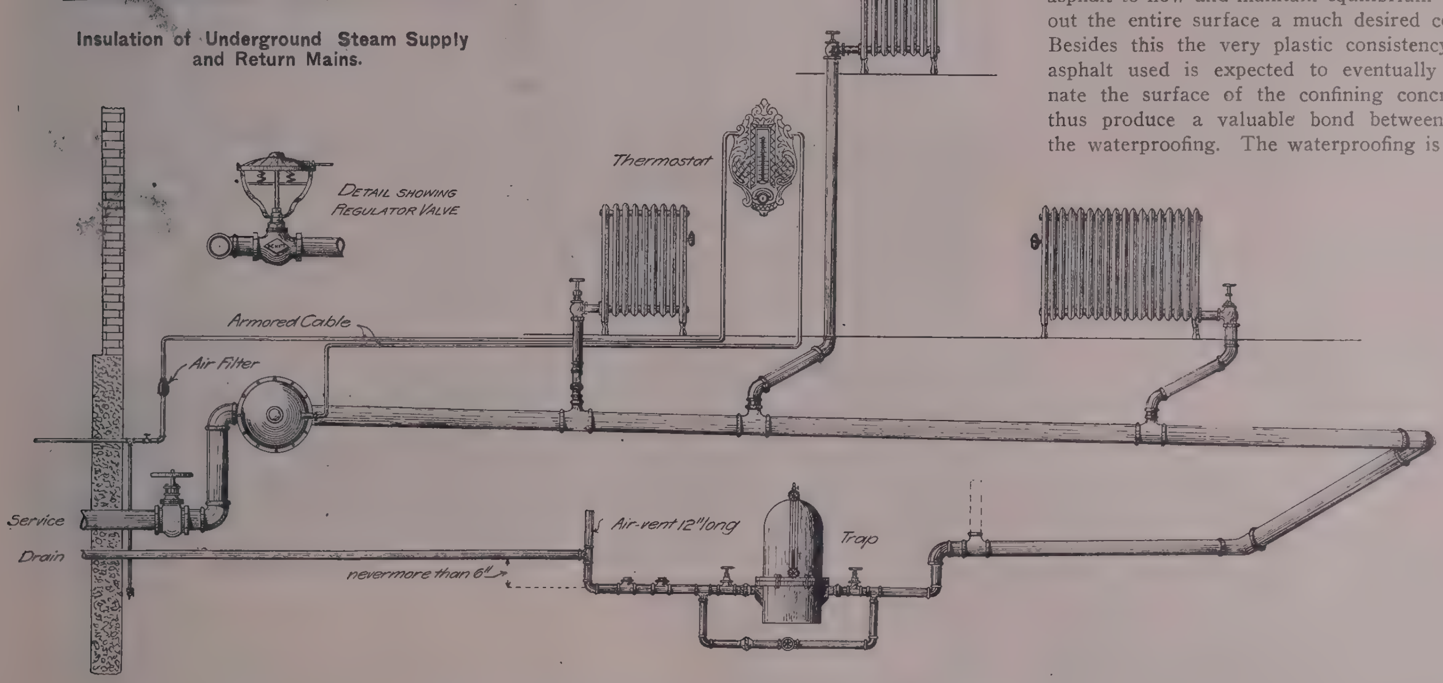
The power station is a two-story building of brick and steel construction, the second floor over the engine room being devoted to a laundry. Steam is furnished by two 6x16-ft. Chandler & Taylor horizontal return tubular boilers, each of 100-h.-p. capacity, with steam piping so arranged as to permit them to supply the heating mains directly or first to the engine driving the lighting dynamo, which exhausts into the heating mains. The generating unit consists of a 70-h.-p. simple horizontal Ideal engine, direct-connected to a 50-kw. General Electric generator. The latter is a 220-volt, direct-current machine, which supplies a two-wire convertible distribution system for both interior and outside (arc) lighting of the campus. Condensation returned from the heating system is largely used for boiler feeding, the condensation being piped to a pump receiver, which automatically discharges into an elevated tank. This tank has also a connection from the water-works system, with float valve, by means of which make-up water is added automatically as needed. The water is supplied from this tank through a feed water heater directly to the boilers by an automatic valve, when operating at low pressure on the heating system, but when under high pressure, the pump receiver is used for feeding.

The steam distribution piping has over 4,500 ft. of mains, ranging in size from 8 in. at the station to 4 in. for individual building branches. It is laid, together with the return pipe, in wood conduits with a special arrangement of insulation, as shown in the sectional view. The steam lines are of wrought-iron, carried on rollers and fitted with loops and bends to allow for expansion, but the return piping is of cast-iron, which was selected owing to the corrosive action of condensation on wrought-iron. For this purpose, the Universal ground-joint piping, manufactured by the Central Foundry Co., New York, was used, thereby avoiding gaskets. A small line in the same trench, but outside the conduit, supplies air pressure at 15 lb. for use in connection with the thermostats and motor valves of the temperature regulation system. Considerable difficulty was experienced in the installation of the conduit line, which in many places required excavation in rock, and in several instances the line is inclined upward at angles of about 45 degrees in mounting terraces to higher elevations.

The radiation in the twelve buildings supplied directly varies from 450 to 4,000 sq. ft., which amounts were estimated in the design of the system on the basis of 700 lb. of steam condensed per square foot per year. The apportionment of radiation relative to the cubical contents of buildings was as follows: Frame buildings, 1 sq. ft. to 34 to 52 cu. ft.; brick buildings, 1 sq. ft. to 57 to 79 cu. ft.; stone buildings, 1 sq. ft. to 70 to 111 cu. ft. The total amount of radiation supplied from the central plant is 22,000 sq. ft., the greater part of which is installed as standard two-column radiators, and for the operation of this only 200 h.-p. in boilers is installed, which is possible owing to the intermittent drawing of steam from the system by each building with the Schott system. The latter factor was also of service in reducing the sizes of mains necessary to supply these amounts of surface.



Insulation of Underground Steam Supply and Return Mains.



Typical Arrangement of Supply and Return Connections to Heating Systems in the Park College Buildings.

Each of the buildings is supplied on the one-pipe system, the steam entering through a motor-control valve automatically operated from a thermostat located in a position of the building which will give representative indications of the average temperature therein. A submerged check valve in the return connection of the service pipe allows condensation to flow out freely but closes to the atmosphere, while Duram automatic vacuum air valves on each radiator similarly allow air to escape but close against the atmosphere, so that the system frees itself of water and air and tends to operate at a pressure slightly below atmosphere. The return lines, however, operate at atmospheric pressure at all times, and the use of a vacuum return pump is thus avoided.

The plant was installed for Mr. H. B. McAfee, business manager of the college, by Mr. W. H. Schott, heating engineer and contractor, of Chicago. The temperature control equipment, automatic vacuum air valves, and traps were supplied by the Schott Specialty Co., Chicago, Ill.

Waterproofing the Substructure of the West Street Building, New York.

The 155x110-ft. steel-cage office building now under construction on West St. at the foot of Cedar and Albany Sts., New York, will be known as the West St. Building, and will have a height of twenty-eight stories above the street level and two stories below it. The foundation piers for the columns have been carried down to rock and the general excavation around them made to a depth of about 17 ft. below mean high tide, the lowest part of the cellar floor being 15 ft. below that level. The bottom of the pit between the piers is covered with concrete on which a waterproofing course will be laid and protected by a concrete floor. The waterproofing is also continued over the pier tops and is flashed up the outside walls to a line above the ground-water level, thus making a continuous surface having a total area of about 35,000 sq. ft., designed to exclude all exterior moisture and resist the maximum theoretical hydrostatic pressure.

The upper surface of the concrete foundation is carefully smoothed and the waterproofing is applied in as large a section as can be made ready. Each section is first mopped with asphaltic pitch of a consistency that is "tacky" at ordinary atmospheric temperature, say 60° Fahr. A layer of special fabric is then applied, mopped with asphaltic tar, another layer applied, mopped, and so on until the required thickness of about 3/8 in. is secured with six-ply of the fabric. The fabric itself is known as "Siaster" waterproofing fabric, and consists of burlap saturated by a special process with asphaltic pitch, which hardens sufficiently to be elastic and not sticky at ordinary atmospheric temperature. It is delivered at the site in rolls 3 ft. wide, each containing about 450 sq. ft., and weighs about 0.12 lb. per square foot. In applying the fabric care is taken to overlap all edges of each course about 2 in. In the following course the joints are made midway between those of the first course and alternate in successive courses so as to provide a complete shingled arrangement and secure absolute continuity of each ply. On the walls of the building the waterproofing is carried up on hollow tile to which it is applied the same as for horizontal concrete surface.

An advantage claimed for this system of waterproofing is that the textile nature of the burlap possesses sufficient tensile strength to afford very material reinforcement to the waterproofing proper and greatly diminishes the danger of rupture or injury to the latter. It also enables the joints between old and new work to be made satisfactorily. One of the troubles of joining old to new waterproofing has been the difficulty of securing a clean contact surface. Here this is obviated by separating all of the different layers of fabric for a few inches along the line of the joint. They can be readily pulled apart, stripped up like the leaves of a book, and the corresponding layers in the new portion of waterproofing successively matched in between them so as to provide perfect overlapping and dovetail the old and new work together. Another advantage is stated to lie in the permanently plastic consistency of the asphalt pitch mopped over the fabric. The final pressure of the confining structure is sure to be sufficient to cause the plastic asphalt to flow and maintain equilibrium throughout the entire surface a much desired condition. Besides this the very plastic consistency of the asphalt used is expected to eventually impregnate the surface of the confining concrete and thus produce a valuable bond between it and the waterproofing. The waterproofing is protected under the bearings of the steel work by sheets of 5-lb. lead interposed between the waterproofing and the bases of the column pedestals or the bearings of the foundation girders, thus enabling the latter to be moved and adjusted without danger of punching through the waterproofing.

Mr. Cass Gilbert is the architect of the building, and Mr. Gunvald Aus is the consulting engineer. The John Peirce Co., Mr. George B. Walbridge, superintendent, is the general contractor. The building is owned by Gen. Howard Carroll, who is also the president of the Sicilian Asphalt Paving Co., contractor for the waterproofing, of which Mr. Herbert Paschke is in charge.

THE WEAR OF ROADWAYS under the charge of the Metropolitan Park Commission of Boston has been seriously increased by high-speed automobiles, and the expense for repairs has correspondingly increased beyond what was anticipated when the roads were built. With a view to securing an improved surface, experiments have been made with tar and petroleum treatment, but no satisfactory result has been secured thus far.

The Equipment of Two Berlin Power Plants.

By Franz Koester.

The original equipments of the Moabit and Oberspree power plants of the city of Berlin are prabably well known to the technical world on account of their special features of design and especially their extremely economical operation. The capacities of the plants as well as those of the individual units are large compared to the average continental plant. What modern practice in steam engineering has obtained on the continent of Europe may be realized from the fact that two 6,500-h.-p. engines have been installed at these two stations, consuming under normal conditions only 8.8 lb. of steam per indicated horse-power-hour and it may be of interest to give here a brief detail description of the design of these prime movers. One of the engines is designed by the Goerlitzer Machine Manufacturing Co., and is installed in the Oberspree power plant, while the other is designed by Sulzer Bros., and is installed in the Moabit station.

The first engine is of the horizontal four-cylinder triple-expansion type, arranged with a high-pressure and low-pressure on one side and an intermediate and low-pressure cylinder on the other side of a common shaft which carries the revolving field of the generator as a fly wheel. The high-pressure cylinder has a diameter of 40⅛ in., the intermediate cylinder 66⅝ in., and the two low-pressure cylinders each 72⅞ in., the common stroke being 66⅞ in. The speed is 83 r.p.m. The engine working under a pressure of 12½ atmospheres (183.75 lb. per square inch) at a total temperature of 572° F. develops at 11 per cent. cut-off, 2,920 i.h.p.; at 22 per cent., 4,580 i.h.p; at 28 per cent., 5,300 i.h.p.; at 33 per cent., 5,690 i.h.p.; and at 50 per cent. cut-off, 6,500 i.h.p., equivalent respectively to 2,540, 4,060, 4,760, 5,120 and 6,000 b.h.p.

The high and intermediate pressure cylinders lie farthest from the generator, thus facilitating the steam pipe connections and avoiding as much as possible the placing of highly heated parts close to the generator. Therefore the two low-pressure cyclinders are bolted directly against the frame of the cross-head guides, a practice common in Europe. Between the high and low-pressure cylinders are distance pieces with openings at the top to provide access to the stuffing boxes as well as the couplings of the piston rods, which are formed as blocks sliding on flat guide plates. The extension rod of the high-pressure cylinder has a similar construction. In order to prevent excessive weakening of the frame on account of the metal cut away from these distance pieces and yet to assure sufficient free acces to the piston rods, heavy distance bolts are provided, as shown in the illustration, taking up the strain of the reciprocating motion. On account of the large dimensions the engine frame is made in two pieces, the cross head guide and the main shaft bearing each having a weight of 44 tons, while each low-pressure cylinder weighs 33 tons, the total weight of the engine being 480 tons. The shaft is hollow and rests on each side in a bearing 43⅛ in. long by 26½ in. in diameter and carries at its center point, the revolving field weighing 110 tons, while the shaft itself weighs 30 tons.

As these engines operate with steam at a temperature of 572° Fahr., the low and intermediate pressure cylinders are steam jacketed, but not the high-pressure cylinder. The heads are also steam-jacketed and the steam used for this purpose is supplied at a pressure of 75 lb. per square inch. It will therefore be seen that these cylinders are heated to a fairly high temperature, first because the steam is directly superheated and second because in being throttled down without doing any work it is still further superheated. The construction of the cylinder heads is such that the great heat in the cylinders does not interfere with the stuffing boxes, as these are brought out as far as possible from the heads.

Each cylinder is equipped with four four-seated Collmann poppet valves. Both valve-controlling shafts are operated from the main shaft by worm and wheel, with the exception of the high-pressure cylinder, whose valves are operated by an auxiliary shaft driven by spur gears. A delicate spring governor of the Hartung type is operated from one of the main governor shafts extended beyond the spur gears. This is done by means of a worm and wheel.

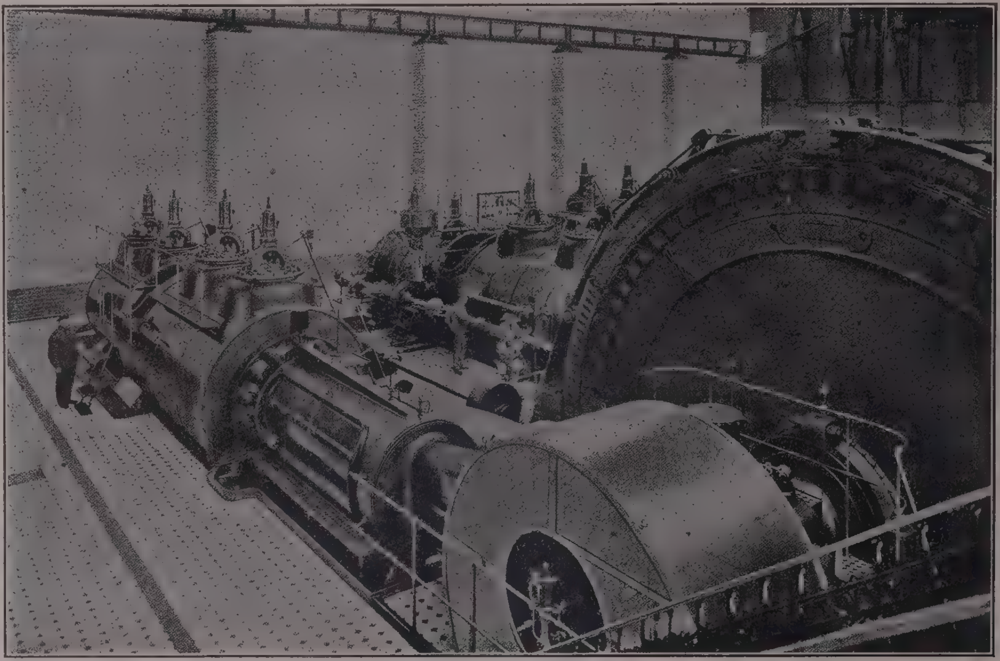
All pistons are provided with Ramsbottom rings. For reducing the piston wear to a minimum and for keeping it uniform, the previously mentioned sliding couplings are provided. A feature of great importance is the forging of the piston rods so that when supported horizontally they are absolutely straight, which is accomplished by forging the rods so that the middle is slightly off center, then turning down with a special device so that when the rod is supported in the two stuffing boxes the weight forces it down into a straight line.

A wet jet condenser, located in the basement, is also operated from the crank of this engine.

The Sulzer engine is also a four-cylinder, triple-expansion engine. Its dimensions are, high-pressure cylinder, 51¼ in.; intermediate cylinder, 60⅛ in., and the two low-pressure cylinders, 72⅞ in.; with a common stroke of 66⅞ in. and a speed of 83 r.p.m. This engine, operating at a pressure of 12 atmospheres (176.4 lb.) and a steam temperature of 572° Fahr., develops at 15 per cent. cut-off 3,450 i.h.p.; at 23 per cent., 4,470 i.h.p.; at 32 per cent., 5,490 i.h.p., and at 50 per cent. cut-off, 6,500 i.h.p., respectively, equivalent to 3,000, 4,000, 5,000 and 6,000 b.h.p. The arrangement of cylinders is practically the same as that of the former engine. Except in the high-pressure cylinder, the cylinders, including the heads, are heated. Each cylinder has four four-seated poppet valves, two at the top and two at the bottom. Access to the lower valves is from the basement. They are operated from the main shaft by means of a worm and wheel. The governor is also of the Hartung type. The engine shaft is supported on bearings 22½ in. diameter by 45¼ in. long, the center part supporting the generator being increased to 33½ in. in diameter. On account of the weight of the revolving part of the generator, 24.4 ft. in diameter, the bearings are enclosed in jackets through which running water is passed. This same water also serves to cool the lower part of the cross-head guides. The water is circulated by means of a small centrifugal pump. From each crank is operated a double-acting air pump of a wet jet condenser located in the basement floor. The stuffing boxes are provided with a metallic packing manufactured by the United States Metallic Packing Co.

Tests made on this engine with a pressure of 12.1 to 12.8 atmospheres at a temperature of 300° C (572° F.) gave an average steam consumption 4.03 kg. (8.806 lb.) per indicated horse-hour.

Each engine is connected to a 4,700-kw. generator, the total weight of which is 184 tons, the frame being 50 tons. The armature frame is built in four parts made up of laminations held together by side plates with no additional covering over the laminations, thus securing an exceptionally good circulation of air. The armature winding is connected in Y for a phase tension of 3,460 volts. As the speed is 83 r.p.m. and there are 72 poles the frequency is 100. At full load 42 kw. are required for excitation.



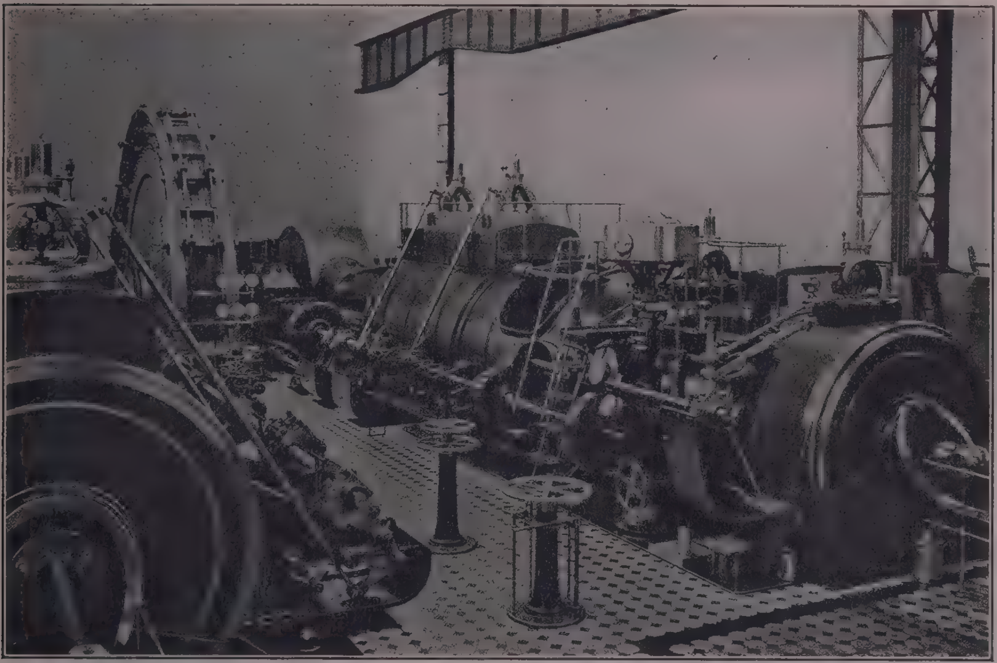
Sulzer Engine at the Moabit Power Station.

The Cost of Laying Water Mains in the cities of New Jersey cannot be assessed against abutting property, according to a decision, 63 Atl. Rep. 170, recently made by the Court of Errors and Appeals. The official syllabus of the opinion reads: "The imposition upon lands adjoining a public street, in which is laid a pipe for the distribution of water for the use of a city and of its inhabitants, of a fixed definite sum per front foot, to be paid by the owner, for the expense of such pipe, cannot be supported under the power of general taxation, nor under the power to tax property benefitted by a local public improvement because of, and not in excess of, benefits. Such a pipe laid under the roadbed of a public street is in no sense an appendage to or a part of the adjoining lots, as a sidewalk may be, nor could a requirement that property owners should lay the same at their own expense be supported under the police power." This decision, while conforming with other New Jersey decisions, is contrary to those of the courts of many other States and is not wholly just from an engineering point of view.

Heating the Edgar F. Smith Dormitory, University of Pennsylvania.

In a paper read recently before the Franklin Institute by Prof. Henry W. Spangler, the results of an interesting series of comparative tests of steam heating in a dormitory building with both hand control and automatic regulation were presented. The building was the Edgar F. Smith dormitory of the University of Pennsylvania in Philadelphia, which was placed in use in the fall of 1904. It is one of a group of twenty-one buildings, under a common roof, but divided into separate houses, each with a separate entrance from an interior quadrangle. The Edgar F. Smith house contains 32 apartments, on four floors and a portion of the basement, and is used for living purposes only, accommodating 47 students.

The dormitory buildings are all heated and lighted from a central power plant about 1,200 ft. distant, the steam main extending about 2,000 ft. from the boiler house to the farthest building. In the portion of the dormitories first built, housing 361 students, the heating is accomplished by indirect radiators in the basement, with independent mixing dampers controlled from each room. Difficulties were experienced with this system, however, as several rooms are heated from each stack of indirect coils and the control was thus not entirely satisfactory. An open window in a room on the windward side of the building would permit a cold back draft down into the heating stack in the basement and thence up to other rooms supplied from it, and thus entirely cut off the supply to the room with the open window. In the second lot of houses built, consisting of 146 apartments, direct radiation was installed for heating, with an auxiliary fan system for use in very cold weather. The service obtained from the latter was, however, so small that after a few of the direct radiators had been enlarged, the fan system was abandoned. It was accordingly decided to heat the Edgar F. Smith house by direct radiation, the steam main being carried up to the attic for connection to drop risers and the radiation connected on the two-pipe system.



Goerlitzer Engine at the Oberspree Power Station.

This building is 35x70 ft. in size and abuts on the west end against the older houses of the row, while the east end is left a blank wall to permit of additions. The entrance is on the south side, which faces the university quadrangle, while the rear side facing the street has northern exposure. There were large amounts of window surface to be counteracted and the system was accordingly proportioned with considerable care. The purpose of the design was to maintain temperatures of 70° F. in the living rooms, 60° F. in the halls, and 50° F. in attic and cellar. Each room was treated separately, a special blank form being used for recording all governing conditions, from which the expected heat loss from the room was determined, on the basis of 1 sq. ft. per 300 B.t.u. loss per hour. Table 1 gives the cubical contents of the various rooms and the distribution of radiation, together with the ratio of heating surface to cubical contents for each room. In the latter ratios, a wide variation is to be noted, reaching the maximum of 188 in well-protected rooms with small glass exposure and a minimum of 44 in the most exposed portion of the building. No radiation was installed in the halls, except in the vestibule at the entrance.

Steam is furnished to the system by a 5-in. branch from the underground main from the power plant, which is taken into the building in the basement and carried up to the attic for the supply of nine drop risers. The latter are of 1-in. and 1½-in. pipe, with 1 in. of cork sectional covering, and were in most cases concealed in chases. Connections to the radiators are made through hand control valves in part and automatic control valves of the thermograde type upon the remainder. The latter valves were supplied by the Thermograde Valve Co., Boston, Mass., for comparison with hand regulation and were installed on a guarantee to give satisfactory results. The distribution of these valves in the various rooms is indicated in Table 1 by "T," the radiators controlled by hand valves being marked by "H"; those neither marked "T" or "H" were not under test. There were eighteen rooms equipped with thermograde control, embracing 33,125 cu. ft. of interior volume, 2,915 sq. ft. of outside wall and 455 sq. ft. of glass surface, for heating which 406 sq. ft. of radiation was installed; of the rooms on hand control under test, there are 22 having 29,720 cu. ft. of interior volume, 1,935 sq. ft. of outside wall and 34 sq. ft. of glass surface, for heating which 282 sq. ft. of radiation was installed The distribution and connections were such that all radiators with thermograde control could be served by one set of return lines and those on hand control by another, thus permitting the condensation returned from either system of control to be measured. The return connections from the radiators are all ¾-in., with special return check valves, dropped to about 4 in. below the radiator outlets; those from the hand control radiators discharged through a trap and thence into a tank and hot-water meter for measurement. As it is necessary for all returns from the thermograde system to operate at atmospheric pressure, the return risers from the radiation thus equipped are carried up and connected together in the attic and vented through the roof, while at the bottom they discharge into a tank which is also vented and thence to a meter for measurement. The meters of both systems, which returned the condensation to the power plant, were carefully calibrated for accuracy.

Table I.—Cubic Feet of Contents and Square Feet of Radiation in Rooms.

Room.	Volume.	Radiation.	Ratio.	Room.	Volume.	Radiation.	Ratio.
1	1080	9	120	219	1575	14-T	113
2	2160	14	154	220	1215	10	122
3	900	9	100	221	945	7-H	135
4	-1575	14	113	222	2160	16-T	135
5	2385	14	70	223	1125	7-H	161
6	1260	18	70	Hall	2790		
1st hall	1390			300	1620	9-H	180
Vstbul.	1035	21		301	1260	12-H	105
100	1125	6-H	188	302	1125	12-H	94
101	2160	14-H	154	303	2385	21-T	114
102	945	9-H	105	304	2115	24-T	88
103	2340	24-T	97	315	2070	28-T	74
104	2700	27-T	100	316	2250	21-T	107
113	945	14-T	68	317	1215	10	122
114	1665	14-T	119	318	1125	12-H	94
115	1575	18-T	88	319	1215	28-T	74
116	1215	12	101	320	1620	12-H	135
117	945	9-H	105	Hall	3465		
118	2160	14-H	154	400	1230	15-H	82
119	1125	9-H	125	401	1200	21-H	57
Hall	2790			402	1310	24-T	55
200	1125	6-H	188	403	1555	27-T	57
201	2160	14-H	154	412	1555	27-T	57
202	945	10-H	95	413	1300	28-T	46
203	2340	24-T	97	414	800	18	44
204	2700	27-T	100	415	1155	21-H	55
217	945	14-T	68	416	1250	18-H	69
218	1800	18-T	100	Hall	2665		
Total for entire building........					90790	810	112

Readings of these meters were taken regularly every day at noon throughout the winter of 1904-5, together with the outside temperatures and the temperatures of the condensation returned from both the hand control and the thermograde systems. It was found that the average temperature of the condensation returned from the latter system was 89° F., while that returned by the hand control system averaged 150° F. This was due to the fact that the operation of the latter system is intermittent, allowing parts of the radiators to act as hot water radiation until the return check valves open to discharge. Table 2 presents a summary of the results that were obtained throughout the winter, which are here grouped in ten-day average values from the time steam was turned on in the fall until it was turned off at the end of March. The relative amounts of condensation returned by the two systems indicate, when compared with the mean outside temperatures, a much closer regulation with the thermograde system than with hand control. With hand control, while the amount of heating used decreases somewhat as the outside temperature increases, the value does not tend to disappear at 70° F.; in other words, a much greater consumption of steam is inevitable in mild weather with hand control than with the automatic thermograde system. A curve plotted by the author to show the relation of condensation returned from the two systems to the outside temperatures indicated that with the automatic system the amount of steam used tends to approach zero at 70°., thus showing real heat regulation, which was not the case with the hand control.

The temperatures observed in the various rooms ranged very close to 70° F., averaging slightly above that in the living and sitting rooms, and slightly below in the bed rooms. It is to be noted that the rooms were almost invariably aired thoroughly during the morning cleanings, and in many cases windows were kept open by the students in the most severe weather. In none of the rooms was difficulty experienced in heating to 70° F. if desired. The corridor temperatures averaged from 58° to 65° F. The average temperature was noted in the attic on Dec. 14 and found to be 64° F., with an outside temperature of 19° F., and on the same day, that in the cellar was 69° F. On Jan. 26, with an outside temperature of 14° F., that in the attic averaged 54.7° F.

A difference was introduced in the conditions of the test in the first week in January, 1905, by the application of weather-stripping to all windows with northern exposure, the result of which was that the amount of steam required by the thermograde system was lessened by about 10 per cent. through the remainder of the winter. With the hand control, however, an unexpected result was observed, for when the outside temperature dropped below 33° F. there was an economy effected, but with the temperature above 33° F., the steam used was more with the windows weather-stripped than without. The cost of weather-stripping the windows was about $90 and the saving per year effected for the rooms equipped with the thermograde valves was found to be $12.52.

Table 2.—Gallons of Steam Condensed per Square Foot per 24 Hours.

	Mean temp.	Hand control.	Thermograde.
Oct. 9; 19	59.6° F.	0.638	0.187
Oct. 19; 20	53.9	0.520	0.228
Oct. 29; Nov. 8	47.4	0.694	0.346
Nov. 8; 18	42.2	0.723	0.432
Nov. 18; 28	43.6	0.752	0.368
Nov. 28; Dec. 8	35.4	0.870	0.518
Dec. 8; 18	25.5	0.926	0.678
Dec. 18; 28	31.3	0.858	*0.522
Dec. 28; Jan. 7	36.1	0.885	*0.446
Jan. 7; 17	30.3	0.926	0.650
Jan. 17; 27	30.0	0.886	0.589
Jan. 27; Feb. 6	20.4	0.995	0.656
Feb. 6; 16	23.6	0.939	0.579
Feb. 16; 26	32.6	0.923	0.518
Feb. 26; Mar. 8	31.4	0.843	0.507
Mar. 8; 18	36.0	0.834	0.445
Mar. 18; 28	50.0	0.712	0.262

*Holidays. Beginning with Jan. 7, the north windows had weather strips.

From the results obtained, the author deduced the following formulas connecting the outside temperature and the amount of steam condensed with both the automatic control and the hand control systems, y being the gallons of steam condensed per square foot of radiator surface per 24 hour, and x the outside temperature:

Plain windows, thermograde control—

$$y = 1.0792 - .0157\ x$$

Plain windows, hand control—

$$y = 1.369 - .015\ x$$

Weather-stripped windows, thermograde control—

$$y = .9901 - .0146\ x$$

Weather-stripped windows, hand control—

$$y = 1.21 - .0103\ x$$

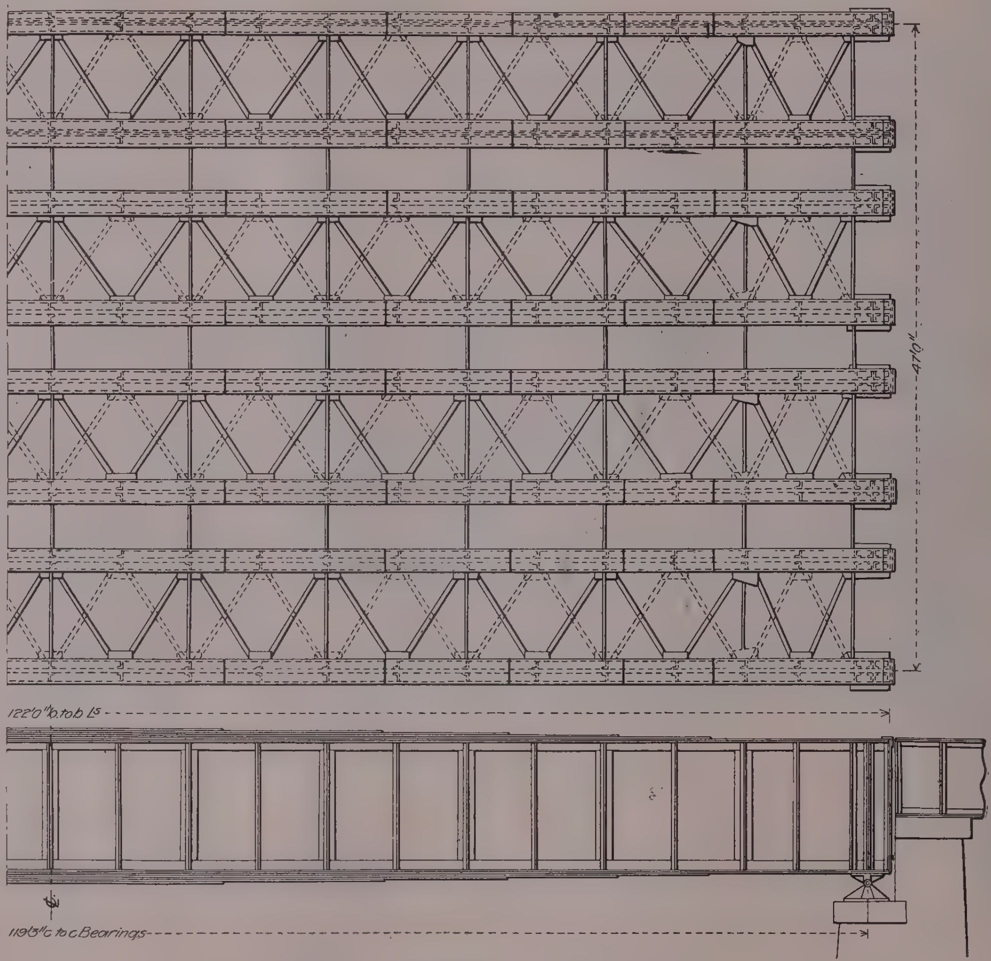
As the condensation returned from the automatic system was 61° cooler than that returned by the hand-controlled system, the real value of the former system is less than that shown by the amount of return water by 5.9 per cent., as this much additional heat must be supplied at the central power station before the condensation returned is again converted into steam. But with this taken into account there was still considerable economy shown by the automatic system. The charge made against the dormitories averaged 20.15 cents per gallon of condensation returned per year, which covered the cost of fuel at $3 per ton, labor, repairs, and all other items except the fixed charges. On this basis the total charge against this building would, with all windows weather-stripped, be $110.92 per year, whereas with the hand control system and all windows weather-stripped the charge would be $197.87 per year. If the system was operated without weather-stripping on the windows the relative charges would be, as shown by the condensation returned, $123.44 per year for the automatic system, $187.80 per year for the hand control. It was noted that the installation cost $473.34 more with the automatic valves than with the ordinary hand valves, and that depreciation and repairs are likely to be slightly more with the former equipment, but allowances had been made for these items in the above figures.

Cost of Dams for the United States Reclamation Service.

One of the most surprising features connected with the work of the Reclamation Service, as well as one affording the highest gratification to the officers in charge is the cost of structures compared with those which have become familiar to engineers in the East. When the reclamation work was inaugurated it was a matter of conjecture whether or not the standards of cost for dams, canals, and other works that had been established by engineering practice in the eastern part of the country, could be relied upon as a basis of estimates of the cost of the proposed western structures. As the work has progressed it has become more and more evident that many classes of engineering work in the West can be performed considerably cheaper than in the East, and at the same time the natural conditions are such that these structures are more economical and effective.

If we take, for example, the three great masonry dams now being erected for storing water, viz., the Roosevelt dam in Arizona, the Pathfinder dam in southeastern Wyoming, and the Shoshone dam in northwestern Wyoming, we shall find that the effective storage capacity and costs are far below those of some of the great eastern dams like the new Croton in New York and the Wachusett in Massachusetts. The heights of these dams are as follows: Roosevelt, 280 ft.; Pathfinder, 210 ft.; Shoshone, 308 ft.; new Croton, 297 ft., and Wachusett, 207 ft. These heights are measured from the foundation stones to parapet in each case, and they show that the Shoshone is the highest, while the new Croton is second and the Roosevelt third. If, however, the height above the river bed be considered, that is, the effective storage height, the new Croton is the lowest. The order is then as follows: Shoshone, 240 ft.; Roosevelt, 230 ft.; Pathfinder, 200 ft.; Wachusett, 185 ft., and the new Croton, 157 ft. In other words, about 50 per cent. of the masonry in the new Croton dam is below ground and is serviceable for foundation purposes only.

It is interesting to note the comparative reservoir capacity. While the new Croton dam is the largest in the world from the standpoint of its amount of masonry, the storage capacity of the reservoir formed by it is by far the lowest of any of those above mentioned. In fact, from a standpoint of storage economy, the new Croton reservoir is one of the poorest that has been constructed in recent years. The dam contains 833,000 cu. yd. of masonry and was erected at a cost of $7,600,000. The capacity of the reservoir formed by it is 4,000,000,000 cu. ft., or a cost of $1,900 per million cubic feet storage. Similar figures for the Wachusett dam show that it contains 280,000 cu. yd. of masonry, and was erected at a cost of about $2,000,000. Its storage capacity is 8,400,000,000 cu. ft., or a cost of $238 per million cubic feet storage. In contrast to these excessive costs the three western dams, appear remarkable. The Roosevelt dam, for example, contains 350,000 cu. yd. of masonry erected at a cost of $3,850,000, unless the contract prices are exceeded for reasons



Half Plan and Elevation of Four-Track Span.

that cannot be foreseen now. The capacity of the reservoir is 61,000,000,000 cu. ft. or fifteen times that of the new Croton, and about 7½ times that of the Wachusett. The cost of this dam per million cubic feet storage is only $63.16. Even more remarkable appears the Pathfinder dam. It contains 53,000 cu. yd. of masonry, erected at a cost of $1,000,000. The capacity of the reservoir is 43,560,000,000 cu. ft., or more than ten times that of the Croton. The cost of the dam per million cubic feet storage is therefore only $22.95 as against $1,900 for the new Croton, and $238 for the Wachusett. Similar figures for the Shoshone dam, the highest in the world, are: cubic yards of masonry, 69,000; cost, $1,000,000; capacity of reservoir, 20,000,000,000 cu. ft.; cost per million cubic feet storage, $50.35.

These extremely low costs have seldom been equalled in the history of reservoir construction, and are due largely to the excellent natural locations for dams which are found in the western country. From this fact it must not be inferred that these western structures are simple engineering works. On the contrary, owing to their isolated location, their inaccessibility by rail and often by wagon, and the erratic and torrential character of the streams, they involve problems which tax the skill and ingenuity of their builders to the utmost.

It is most fortunate that these reservoirs provide enormous storage at relatively low cost, otherwise their construction would not be feasible, as the irrigated land could not bear the expense of the costly structures of the East with their limited storage capacity. The Crotom dam, if it had been constructed in Salt River Valley in Arizona for irrigation, would only supply 23,000 acres, and irrigators would have to pay $330 an acre for stored water, as against $20, the estimated cost from the Roosevelt dam.

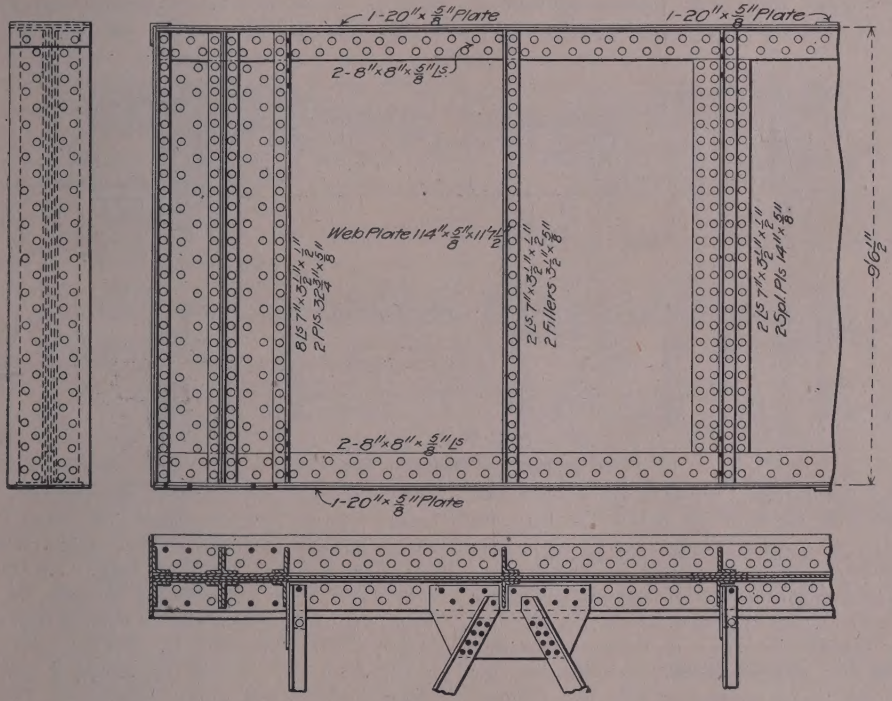
A Portable Telephone Service, the first of the kind ever used, is being installed by the Michigan State Telephone Co., at Detroit. It consists of numerous connection plates or jacks connecting with the exchanges, which are distributed in public places throughout the city, and into these cords of portable telephone outfits in carriages, automobiles, delivery wagons and other conveyances of subscribers, may be inserted anywhere for temporary communication.

A 122-Ft. Four-Track Plate Girder Span.

The longest plate girder span on the Pennsylvania Railroad forms part of the track elevation at Market and Penn streets, in Chester, Pa., on the line of the Philadelphia, Baltimore & Washington Railroad. It consists of four pairs of girders 122 ft. long over all and about 9½ ft. deep, which are seated on masonry piers about 115 ft. apart in the clear. They are braced together with zigzag top and bottom lateral angles and transverse frames between each pair of girders, so as to make essentially four separate parallel spans, each carrying a single track with the cross ties resting directly on the top flanges of the girders 8 ft. apart on centers. The adjacent girders of successive pairs are 5 ft. apart on centers and are connected by horizontal transverse angles 9 ft. apart, which serve to space them, but cannot transmit any stress from one track to the next.

The girders are of the simplest possible construction, designed with special attention to uniformity and duplication of members. The web is 114 in. deep and ⅝ in. thick throughout, and is made in two-panel lengths of 9 ft. 9½ in. except at the ends, where the pieces are 11 ft. 7½ in. long and are reinforced over the bearings by a pair of 8-in. vertical angles. All web splices are made of a pair of 14x⅝-in. cover plates with four vertical rows of rivets having the same number at every splice. At intermediate panel points 4 ft. 11 in. apart, the web is stiffened by a pair of 7 x 3½-in. vertical angles with fillers. The web is cut ½ in. short of the actual length and depth so as to insure clearance at the splices and with the flange cover plates.

The T-shaped top and bottom flanges have a maximum cross-section consisting of two 8x8x⅝-in. angles and five 20x⅝-in. cover plates. Both top and bottom flanges have the same gross area and are made with exactly the same spacing so as to be duplicates except for the connections to the end shoes. The angles are made with two rows of rivets in each flange and are remarkable in that they are rolled full length without splices. Each bar weighs about 4,000 lb., and is one of the longest heavy angles ever rolled. The cover plates are from 32 to 122 ft. long and are made so that the projecting ends of the outside plates splice the joints in the two first plates, each of which is made in two or three pieces. The width of the flanges is maintained at the ends of the girders by a ⅜-in. cover plate riveted to the end web-stiffener angles.

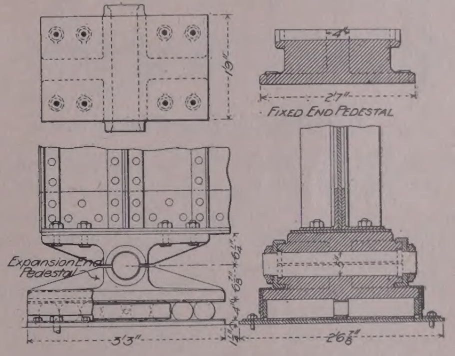


End of Girder and Bracing.

The lateral angles are alike in both top and bottom systems, except that the direction of the diagonals is reversed in each. They are uniformly 5x3½x⅜-in., and are field riveted at both ends to ⅜-in. connection plates field-riveted to the flanges. Transverse frames are made with single horizontal and diagonal 3½x3½-in. angles, shop-riveted together and field-riveted to the vertical web-stiffener angles.

Cast steel shoes 119 ft. 3 in. apart on centers are secured to the lower flanges of the girders with eight 1⅛-in. turned bolts in each. They have continuous semi-cylindrical bearings for 5-in, pins which are seated in corresponding bottom castings or pedestals like the shoes, except that their bases are extended longitudinally and transversely. The pins have solid collars 1 in. wide and ¼ in. thick, turned on each end, which engage recesses in the ends of the shoes and pedestals and, together with flanged rings secured by the nuts, lock the pedestal and shoe together.

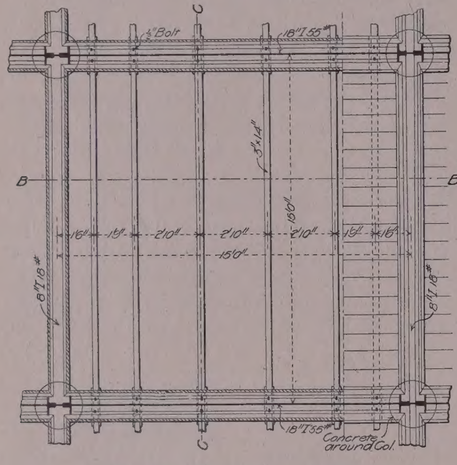
At the fixed end the shoe has a height of 11 in. to the center of the pin and has a planed base seated on a 1⅛-in. planed bed plate with a 1-in. anchor bolt through each corner of shoe and plate. At the expansion end the planed lower surface of the pedestal has a longitudinal guide rib engaging slots in the nest of eight 4-in. rollers on which the pedestal is seated. The rollers move on 4-in. longitudinal strips riveted to a ⅞-in. bed plate. The ends of the rollers have shouldered bearings in side strips and the nest is enclosed by Z-shaped longitudinal pieces bolted to each side of the bed plate so as to engage the edges of the pedestal base, with their top flanges. These are made of pairs of angles riveted together through their vertical flanges and serve to exclude dust and rubbish, but can be easily removed for inspection and oiling. The bridge was built at the Pencoyd plant of the American Bridge Co., and weighed 234,358 lb. for each track.



Expansion End Bearing.

The bridge was built of soft open-hearth steel punched and unreamed except for pieces more than ⅝ in. thick. It was designed according to the standard specifications of the Pennsylvania Railroad Co., which at the time of its construction differed little from the revised requirements now in force. The latter provide for a dead load made up of the steel weight, the timber estimated at 4½ lb. per foot B. M. and 160 lb. per linear foot of track for rails, splices, etc. The live load for each track is a 5,000-lb. train preceded by two coupled consolidation locomotives each weighing 374,000 lb. on a 107-ft. wheel base and having four pairs of drivers 5½ ft. apart with 52,000 lb. on each axle. Wind pressure is assumed at 50 lb. per square foot on the vertical elevation of the unloaded girder, and 130 lb. on the same surface plus a train area 10 ft. high and 2½ ft. above the base of rail, which is assumed to move across the bridge. Anchorage is provided for an assumed train load of 800 lb. per linear foot. Impact allowance recognizing both live and dead loads is provided by the formula, corrected stress, $S = M\ (1 + k)$, where k is a coefficient calculated by the formula $k = 1 - 2R + R^2$. M is the calculated maximum stress, m is the calculated minimum stress, $R = M/m$. In order to insure the stability of bridges under increased live load, calculations were made for a live load 100 per cent. greater than that specified, and if under this assumption $S = M\ (1 + k)$ produced a unit stress more than twice as large as the allowable working stress, the section was increased until that limit was not exceeded. The maximum working stress per square inch were not allowed to exceed 16,000 lb. for vertical loading or 20,000 lb. for combined vertical wind and momentum stress. Rivets were proportioned for bearing and shearing stresses of 24,000 lb. and 12,000 lb. per square inch respectively.

In calculating shearing and bearing stresses in the web rivets the whole of the shear, with its proper increment, acting on the side of the panel next the abutment was considered as transferred into the flange angles in a distance equal to the depth of the girder. The unsupported length of the compression flange was limited to twelve times its width. Rivets connecting the top flange angles to the web are proportioned for a 15-ton driver load distributing over three ties. The web is proportioned for a maximum shearing stress of 12,000 per sq. in. of gross cross section.



Dimensions of Floor Panel.

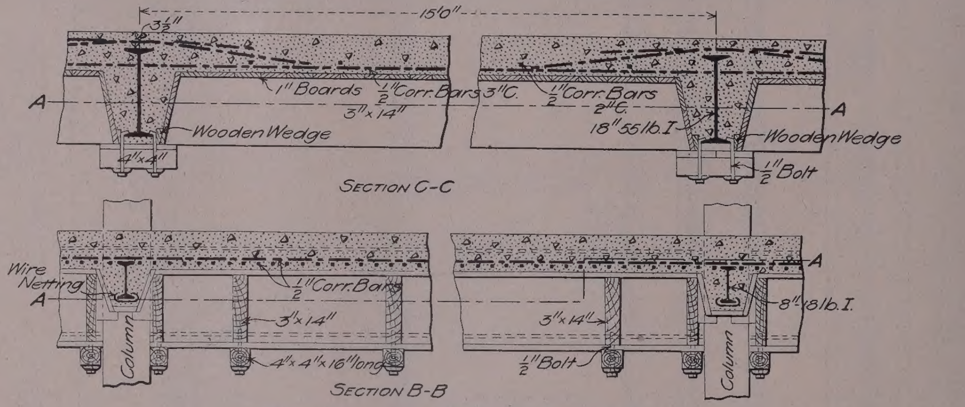
Provision is made for expansion due to temperature variation of 150° Fahr. The expansion rollers are proptioned for a pressure per linear inch not exceeding $1{,}000 \sqrt{d} + 100\, d$, where d is the diameter of the roller in inches. Bed plates are proportioned for a maximum load of 500 lb. per square inch on the masonry.

The bridge was designed and erected under the direction of the engineering department of the Pennsyivania Railroad.

Belting Experiments at the Worcester Polytechnic Institute have thrown much doubt on the validity of the usual theory that the sum of the tensions in both runs of the belt is constant. Prof. W. W. Bird stated at the last meeting of the New England Cotton Manufacturers' Association that the tests showed that, as the load comes on, the belt on the tight side stretches more than the slack side contracts, the result being that the sum of the tensions increases, thus bringing a greater pressure on the bearings. This, he attributes to the variation in the modulus of elasticity due to the element of time. If the belt was non-elastic, like a chain drive, the pressure on the shaft bearings would increase directly as the load, while if the belt were perfectly elastic and could stretch and contract instantly, the pressure would remain constant.

Reinforced Concrete Floors in a Chicago Warehouse.

The North American Cold Storage Co., of Chicago, recently erected a 60 x 70-ft. addition to its sixteen-story building at the junction of the main and north branches of the Chicago River. The addition has a steel-cage frame, with brick masonry side walls and reinforced-concrete floors and roof. The columns of the steel frame are 15 ft. on centers in both directions. The floors are designed to carry a uniform live load of 300 lb. per square foot, with a factor of safety of 4, the contract under which the floors were built stipulating that any two floor panels in the building should be subjected to a test load of 1,200 lb. per square foot. The floor framing consists of 18 or 20-in. I-beam girders in one direction between the columns, with 8-in. 8-lb. I-beams tying the rows of columns together in the other direction. The reinforced-concrete floors thus have a span of 15 ft., being supported on two sides only by the floor girders. The floors are 8 in. thick, including a wearing surface, and are reinforced with ½-in. Johnson corrugated steel bars, spaced as shown in one of the accompanying illustrations. Between the girders and parallel with the 8-in. tie beams the bars are spaced 3 in. apart on centers, 1 in. above the bottom of the slab, with bars 2 ft. apart on centers in the opposite direction and just above the first layer. Every alternate bar in the layer of closely spaced bars is bent up between the center and the end of the span and extended over the top of the I-beam girder and 2 ft. into the concrete of the adjoining floor panel. This method of reinforcement is designed to produce a continuous girder effect, but the floor slabs were considered as simple beams supported at both ends. The concrete used in the floors consisted of 1 part Vulcanite Portland cement, 2½ parts torpedo sand and 4½ parts crushed limestone. The girders and tie beams are imbedded in concrete, and have expanded metal wrapped around their lower flanges to hold the concrete covering the latter in place.



Floor System and Molds for Forming It.

The forms for each floor were suspended from steel girders and tie beams in that floor without any centering or shoring on the floor below. The forms for each floor panel were also independent of those for the adjoining panels. The lagging consisted of 1-in. dressed planks, which were carried directly by 3 x 14-in. plank, placed transversely to the 18-in. I-beam floor girders. These 3x14-in. plank were spaced as shown in the accompanying plan and were carried at each end on 4 x 4-in. blocks suspended from the 18-in. I-beam. Each 4 x 4-in. block was supported by two ½-in. bolts, one on each side of the lower flange of the I-beam. The bolts extended through the 4 x 4-in. blocks and were fitted with washers and taps on the lower end which held the blocks in position. The ends of the 3 x 14-in. planks were cut to the angle of the concrete in which the I-beam girders are incased, and rested on the ends of the 4 x 4-in. blocks. The lagging of the form for the bottom and sides of the concrete around the I-beams was carried by the 4 x 4-in. blocks and the ends of the 3x14-in. planks. The lagging on the underside of floor was carried on the 3x14-in. planks.

The centering was commenced for the second floor as soon as the progress of the steel work would permit. The work on the floors closely followed the erection of the steel frames and preceded the building of the brick side walls. The concrete work from the second floor to the roof inclusive, embracing the protection of the columns and girders and the laying of the floors with their finished surfaces, was completed in 4 weeks, an entire floor being put in during three 8-hr. shifts. The completion of the first floor was delayed until a mechanical plant for the building had been installed.

A Foote Bros. continuous concrete mixer and a cylindrical batch mixer made by the National Concrete Mixer Co., were used in making the concrete. One of these was set up in the basement and the other in the street along one side of the building. A double platform barrow hoist, made by the Thomas Elevator Co., was used to elevate wheel barrows in which the concrete was hauled from the mixer to place. The forms were left in position ten days, so that eight complete sets of floor forms had to be built. The forms were taken down by removing the nuts on the lower end of the ½-in. bolts hooked on the lower flanges of the I-beam girders. The bolts were released from the concrete by removing tapered wedges, which were placed between the lagging of the form and the bolts before the concrete was placed. Each set of forms was thus available for use again, but owing to the rapidity with which the building was erected could be used but twice.

After the completion of the floors, a panel was selected on the fourth and one on the eleventh floor for testing. In order to secure the required load of 1,200 lb. per square foot, 135 tons of pig iron were placed on each of the 15x15-ft. panels. Under this loading the deflection at the center of the panel was ¼ in., half of which occurred in the girders and the other half in the floor span. No evidence of checking or hair cracks, nor any other indication of failure under the heavy loading were apparent. The total load was left on the floor about 4 hr., after which a loading of 1,000 lb. per square foot was left on the floor for several days. The floors have also been loaded in service since the construction tests were made considerably beyond the capacity for which they were designed. Coal was recently piled on the first floor to the ceiling, in anticipation of the coal strike, without any apparent injury to the floor.

Mr. Frank B. Abbott, of Chicago, was the architect for the building. The reinforced concrete work was designed and constructed by Mr. Alexander C. Warren, of Chicago.

Hollow Concrete Foundation Piers.

The United States Post Office at Cleveland, Ohio, is a five-story 220x200-ft. building with heavy self-supporting masonry walls which carry the floors and roof. The footings of the outer walls are from 12 to 15 ft. wide. They are carried down in most cases to a depth of 25½ ft. below the basement floor or about 41 ft. below the original surface of the ground, except in the boiler room where they are about 10 ft. deeper. The soil here consists of about 10 ft. of fine sand below which there is a deep horizontal stratum of soft wet clay. In order to reduce the weight of the deep concrete foundation a special construction was adopted for the footings which are practically continuous under the outer walls and form four large isolated piers and several smaller ones for a few interior columns.

The piers are spaced 2½ ft. apart in the clear under the walls and are made of monolithic cellular concrete, as indicated in the detail drawing, thus saving about one-half the volume of concrete which would be contained in a solid pier and materially diminishing the load on the clay where it was important to make it as light as possible. The entire site was first excavated 12 in. below the basement floor, and the sides of the pit were retained by sheet piling and inclined bracing. The clay was so soft and wet that it was not considered advisable to work in large trenches, so the area of the wall footing was cut up into small sections, thus determining the sizes of the separate wall piers.

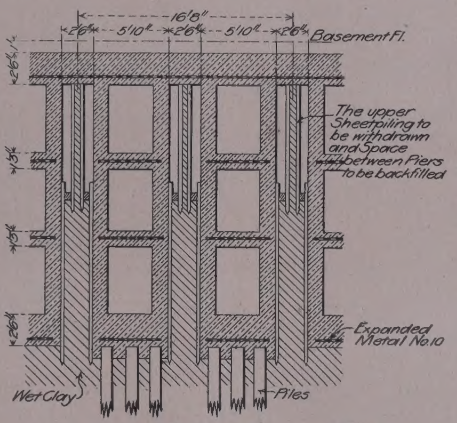
Each pit was excavated with ordinary sheeting and the bottom was covered with 12 in. of concrete on which was placed a layer of No. 10 expanded metal. More concrete was then added to form a mass 2½ ft. thick, on which boxes of thin rough boards were placed to form permanent cores. Concrete was filled around them, against the face of the sheeting, making the walls of the piers, and was spread 6 in. thick over their tops. Another layer of expanded metal was then put in position and covered with more concrete, a second core was set, concrete was placed around and above it, and finally a third sheet of expanded metal was placed and another core built in, thus carrying the pier up nearly to subgrade of the basement floor.

The upper sets of sheet piles were withdrawn, and the spaces between the piers were back-filled and rammed level with the top of the concrete. The tops of the piers and the spaces between them were then covered with a 6-in. layer of concrete on which expanded metal was spread and finally the whole was filled in with concrete to form a continuous horizontal slab 2½ ft. thick with its surface 12 in. below subgrade. This afforded a satisfactory footing on which the masonry was built in the usual manner.

When the first pits were sunk the ground was found so soft that it was not considered a satisfactory support for such a large and important building. Piles were therefore driven in the bottoms of the pits and were proportioned to carry the full loads at about 15 tons each. The piers above them were built hollow, as already described, to reduce the weight of the concrete, and because it was cheaper than to make them solid. In one place, where a heavy concentrated load was to be carried, the tops of the piers were finished at a somewhat lower level, and over them were seated rows of longitudinal 15-in. I-beams, web-spliced to make long continuous lines. These were buried in the concrete with their lower flanges 4 ft. 8 in. below the cellar floor. On them were seated grillages of transverse 20-in. I-beams, with a pair of longitudinal beams across their top flanges to serve as distributing girders.

In the center of the building there is an open rectangular court about 80 ft. square, with walls parallel to the sides of the building. These walls do not extend below the second story, where they are carried on box lattice girders 7 ft. deep supported by groups of three columns at each corner of the court. The girders are built into the wall and allow unobstructed floor space below them in the first story, at the same time providing admirable stations for inspectors who can thus maintain complete supervision over the post office room and remain unseen. Each cluster of three columns is seated on a 27x20-ft. foundation pier with its axis parallel to the diagonal of the light court. Each of these piers is of the same type as the wall piers and has eight sets of hollow spaces. There are also three lines of interior columns parallel with the outer walls of the building, which are seated on separate piers, part of them 6½ ft. square with single central hollow spaces, and the others 6½x10 ft. with two hollow spaces in each.

This building was designed under the Tarsney act authorizing competitive designs for Federal buildings. The competition was won by Mr. Arnold W. Brunner, and the foundations and structural steel work were designed by Mr. Gunvald Aus, New York, consulting engineer. Messrs. Wm. Bradley & Son, New York, were the general contractors, and Messrs. Hunkin Brothers & Co., Cleveland, were the contractors for the work here described.



Section of Hollow Concrete Piers.

Book Notes.

The San Francisco disaster has drawn so much attention to the subject of earthquakes that the treatise by Major F. de Montessus de Ballore entitled "Les Tremblements de Terre," (Paris, Libraire Armand Colin), is a specially timely volume. The author has been a student of the subject for many years, in the course of which he secured the records of an enormous number of shocks, nearly 150,000 in all. From these he concludes that earthquakes occur mainly along two zones, coinciding with the geosynclinals of the mesozoic age. In these zones the sedimentary deposits were bent and thrown about in tertiary times, resulting in the formation of the principal mountain ranges. These masses are not completely stable, and when one slips on another an earthquake results. The most unstable regions are those having the most rugged topography, and river courses in such regions are particularly unstable if they are deepening rapidly. The author can trace no general connection between earthquakes and volcanic disturbances. The volume is one so full of data and theory drawn from them that any detailed review of its contents is impracticable in a brief compass; this is hardly necessary, however, for the book is the most comprehensive and authoritative work on the subject, fully bearing out the expectations of the readers of the same author's notable contribution on the same topic to the "Bieträge für Geophysik" in 1900.

Some months ago, the council of the American Institute of Electrical Engineers authorized the republication in a single volume of the series of papers and discussions presented before the Institute under the auspices of its committee on high-tension transmission. The immediate favor with which this collection of papers was greeted by engineers interested in long-distance transmission has led to a similar republication under the title of "High-Power Transmission, Second Volume" of the series of papers and discussions on the subject at the International Electrical Congress of 1904. The demand for these papers comes from a far larger number of engineers than the membership in the Congress, and it is safe to say that the burial of this information in the proceedings of a special organization has locked up data of practical value to a great many engineers. The information in them has been drawn in large measure from the work done in connection with important long-distance installations, and for this reason is particularly useful. It is interesting to notice that in matters of general design there seems to be a complete accord among the authors of the different papers, but in detail design of the line there is practically no uniformity. This is an indication of the influence of local conditions as well as of a lack of agreement in the present views concerning the minutiae of power transmission. The value of the book is therefore great, not only in stating the present state of the art, but also as giving, in the words of the authors of important features of the art, an explanation of the special conditions which led them to prepare the detail designs which they describe. (New York, McGraw Publishing Co., cloth, 8vo, $2.50.)

Morton Memorial. A History of the Stevens Institute of Technology, with Biographies of the Trustees, Faculty and Alumni and a Record of the Stevens Family of Engineers. Edited by Prof. F. De R. Furman. Hoboken, Stevens Institute of Technology; half morocco; quarto, 663 pages, $10.00.

This beautifully illustrated and printed volume is a unique contribution to the history of engineering and engineering education. It was originally planned as a souvenir of the 25th anniversary of Stevens Institute, and the late President Morton devoted much of his time and no little money to the collection of data and the preparation of illustrations for it. After his death the executive committee of the alumni association decided to make the volume a memorial to him, commemorating the period during which he was president. Accordingly the section relating to the history of the Institute was enlarged and that concerning the anniversary celebration was curtailed materially. The review of the work of the Stevens family and the biographies of the trustees and faculty were unchanged, but the biographies of the alumni were cut down. The editorial work involved in the preparation of the volume has been arduous, but has been well repaid by the resulting accuracy of the data and the appearance of the book.

For two reasons the book deserves a place in the public reference library of every city of manufacturing importance. One reason is the inspiring story it contains of the lives and achievements of John Stevens and his two sons. What they did for engineering is hardly appreciated today; they were pioneers in railroad construction, in the propulsion of ships by steam, in projectiles and a host of minor directions. John Stevens was a man of strong character and public spirit. He was treasurer of the colony of New Jersey during the Revolution and his legal training made him an influential factor in the formation period of the nation, particularly in establishing a patent system. In 1798 he had built and run successfully a small steamboat, and in 1804 he built another propelled by twin screws. He established in 1811 between Hoboken and New York the first steam ferry in the world. In 1817 he obtained the first charter granted in the country for a railroad. In 1823 he secured legislation from which grew the Pennsylvania R. R. In 1826 he built a steam locomotive which ran at 12 miles an hour, the first to run in America.

His sons, Robert L. and Edwin A. Stevens, were men of equal force and inventive ability. The first was easily the leading marine architect and engineer of his time, and the list of his inventions and improvements connected with marine engines is a long one. Moreover he was equally successful in designing sailing vesels, and built the yacht "Maria," which beat the "America," the vessel that brought the Queen's cup to this country. He is best known, however, as the first president and chief engineer of the famous Camden & Amboy R. R., of which his brother was treasurer. For it he designed the T-rail, the hook spike and the tie bar. The rails and a locomotive were bought in England, and the road was opened with them. Edwin A. Stevens became the active business manager of the line, as he had shown unusual ability in the management of affairs of large extent and variety. The business skill required to launch and guide such a novelty as a railroad was in those days very great and the marked success of the Camden & Amboy line is a proof of his ability.

It was Edwin A. Stevens who founded Stevens Institute by a clause in his will, which was drawn in 1867. At that time the Cooper Union had been giving instruction to mechanics for about eight years. Mr. Stevens took a great interest in it and, on the advice of Abram S. Hewitt, decided to establish a somewhat similar school, but for engineers rather than mechanics. The second feature of the memorial volume that renders it so valuable to libraries is its record of the Institute founded in this manner. After Mr. Stevens' death there was serious criticism of the project by both educators and men of affairs, but the school of mechanical engineering contemplated by the founder was established. With great shrewdness or great luck, the trustees chose for the president, not an engineer or experienced teacher, but a young lawyer who had turned to scientific research for his life career. The selection of Henry Morton was a most happy one, and under his skillful direction the Institute developed steadily. His successor and former pupil, Dr. A. C. Humphreys, pays this tribute to him in the preface to the memorial volume: "President Morton's wonderful capacity for the rapid acquisition of exact knowledge in every branch of science, combined with a like ability accurately to appraise the value of evidence, enabled him early in life to earn an unrivaled reputation as a scientific expert in patent cases. His extra labors in this field enabled him to meet from time to time the Institute's most pressing pecuniary needs. He gave his great ability, his substance, and his very life to Stevens Institute; for I am convinced that in large measure it was the worry occasioned by the insufficiency of the Institute's endowment, made apparent by the growth due to his successful administration of its affairs, that finally broke down his frail body, never strong enough to keep pace with the demands of his great heart and intellect."

This statement will explain why a Morton memorial volume possesses such importance as a record of educational progress. What the Rensselaer Polytechnic Institute had been for many years in civil engineering, Stevens Institute became almost instantly in mechanical engineering on account of the skill with which President Morton chose his staff and directed the affairs of the college. It was his success that made easy the way for other mechanical engineering schools by demonstrating the value of an education in applied science. When the Institute's first class was graduated few people had much faith in the idea that "book learning" could ever compete with the information acquired in the shop and drafting room. It did not take many years for Dr. Morton to prove by his graduates that the "practical" man could not compete with the technical school alumnus, other things being equal. The story of the development of the Institute, as told in general terms and in the record of the work of the alumni, is very interesting. It might be added that the book was not published for the sake of any pecuniary return, and only the fact that the Institute has a few extra copies gives the general public an opportunity to secure them.

Letters to the Editor.

Engine Wrecks from Cylinder Water.

Sir:—In your issue of April 21 you make some comments on the prevention of engine wrecks from cylinder water that seem to me to be based on an erroneous point of view. It cannot be considered good engineering to rely for such prevention of wrecks on the vigilance of an engine driver or on the breaking of some part of the engine left intentionally weak, when there is an efficient way of getting rid of water coming over from the boilers or the condensation accumulating in the mains. The principal use of steam separators and receivers is to protect engines against damage from water, and the steadily increasing demand for good apparatus of this sort is a proof that it serves its purpose. A good separator of suitable size, properly installed, is surely a better protection than provision for as quiet a breakdown of the cylinder heads as the engineer can design.

Well designed receiver separators, such as the Cochrane, not only take care of all water coming over with the steam, but also permit the size of steam pipes to be kept down to the minimum, prevent shocks due to quick opening and closing of steam valves, and prevent the piping from being injured by sudden and heavy fluctuations of the load on the engine and the attendant variation in the rate of flow of the steam in the main. In other words, they provide near the throttle a reserve steam supply which acts as a balancing valve to prevent any of the fluctuating demands upon the engine from being communicated so rapidly to the steam main as to cause trouble in it from hammering or vibration.

These receiver separators have other advantages than the protection of the piping and engine. They are specially useful in plants where boilers have been added until the steam mains are too small to work satisfactorily under the old conditions; the installation of such an apparatus steadies the flow of the steam, and thus enables the piping to discharge at its utmost capacity, which is impossible when every pulsation of the steam at the throttle vibrates back through the steam main. Moreover, the receiver separator will correct, in a measure, some of the defects resulting from the faulty design of steam piping, such as numerous bends and the formation of pockets.

Yours truly, Steam.

[This correspondent is undoubtedly correct in all his statements. Separators and receivers are the best guards against the troubles mentioned. Unfortunately there has been cheap and worthless apparatus put on the market which has led some engineers to underrate the service to be obtained from good equipment, and there have been numerous cases where excellent separators have been used in such a way that they could not possibly answer the requirements. As a result, there has been some prejudice against the apparatus; where it exists, the only prevention of engine wrecks from water is that in the article printed on April 21. Why any engineer should prefer it to the protection afforded by a good separator or receiver separator properly installed is beyond the ken of The Engineering Record.]

The Am. Inst. E. E. Vote on the Metric System.

Sir:—In order to ascertain the attitude of the membership of the American Institute of Electrical Engineers on the metric system, the report of the Standardization Committee in the form of the following resolutions was submitted for letter ballot to the associates and members residing in the United States, numbering about 3,300:

"The following preamble and resolutions concerning the metric system were favorably reported to the Board of Directors by the Standardization Committee at the Directors' meeting of March 23, 1906. In view of the importance of the questions involved and the possibly differing views of the membership at large, the Board decided to submit the matter to the membership for a letter ballot. It is proposed to transmit the result of this ballot to the Congressional Committee on Coinage, Weights and Measures before May 1:

"Whereas, The metric system of weights and measures offers very great advantages by its simplicity, consistency and convenience in every-day use, as well as in engineering and scientific calculations and computations; and, whereas, these advantages have already been demonstrated by the universal adoption and entirely successful use of the metric system in all civilized countries, except Great Britain and the United States; and whereas, all the electrical units in universal use, such as the volt, ampere, ohm, watt, etc., are metric units; and whereas, the industrial use of these electrical units would be much facilitated by the general adoption of the metric system: resolved, that this committee unanimously recommends the introduction of the metric system into general use in the United States at as early a date as possible without undue hardship to the industrial interests involved; resolved, that this committee favors such legislation by Congress as shall secure the adoption of the metric system by each department of the National Government as speedily as may be consistent with the public welfare."

The returns up to May 5 were as follows: In favor of the resolutions, 1,569; against the resolutions, 178; total vote, 1,747. This vote is not to be considered as the official action of the Institute, but simply to test the views of the members who were sufficiently interested in the matter to cast a vote.

Yours respectfully, Ralph W. Pope.
New York, May 5. Secretary.

A Handsome Stone Bridge recently constructed over the Rhine at Basle has two central spans of 92 ft., one of 89 ft. on either side of these central arches, and one of 80 ft. at each end. There is also a 34-ft. span at one end over a quay. The center pier is 20 ft. wide and the other river piers 10 ft. The bridge carries a 36-ft. roadway with a 11½-ft. sidewalk on either side. The arches are parabolic and the slope of the roadway is such, according to "The Engineer" of London, that the heights of the piers and the lengths of the spans harmonize so as to reduce the difference between the horizontal thrusts on the piers to an immaterial amount. All face masonry is of granite while the remainder is of sandstone. Half the bridge was built at a time, in order to keep the river open to navigation, and it is for this reason that the central pier was made large enough to resist the thrust of one of the central spans without assistance from the other.